GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT INITIATION

Date: 9/18/80

Project Title: Computer-Aided Design for MAF Engineers

Project No: E-20-633

Project Director: Dr. D.W. Halpin

Sponsor: Naval Construction Battalion Ctr.

Agreement Period: From 4/25/80 Until Nov. 30 ~~8/29~~/80

Type Agreement: Order No. N62583/80-M-R534

Amount: $9,800

Reports Required: Monthly Progress; Final

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

L.C. Tucker
Supply Officer
Naval Construction Battalion Center
Port Hueneme, CA 93043
(805) 982-5904/4815

Defense Priority Rating: DO-S1 under DMS Reg. 1

Assigned to: Civil Engineering (School/~~Laboratory~~)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
✓ Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: April 23, 1981

2-22-87

Project Title: Computer-Aided Design for MAF Engineers

Project No: E-20-633

Project Director: Dr. D. W. Halpin

Sponsor: Naval Construction Battalion Center

Effective Termination Date: 11/30/80

Clearance of Accounting Charges: 11/30/80

Grant/Contract Closeout Actions Remaining:

x Final Invoice ~~and Closing Documents~~

_ Final Fiscal Report

_ Final Report of Inventions

_ Govt. Property Inventory & Related Certificate

_ Classified Material Certificate

_ Other ____________

Assigned to: Civil Engineering (~~School~~/Laboratory)

COPIES TO:

Project ~~Director~~ ACM.
~~Division Chief~~ (EES) COORD.
School/~~Laboratory Director~~
Dean/Director—EES
Accounting Office
Procurement Office
Security ~~Coordinator~~ (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other ____________

CA-4 (1/79)

E-20-633

SCEGIT–80–193

COMPUTER AIDED DESIGN FOR MAF ENGINEERS

AN INVESTIGATION CONDUCTED BY
THE SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

By

D. W. HALPIN, Project Director

Prepared for

THE U.S. MARINE CORPS
CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME, CALIFORNIA

Under

PURCHASE ORDER N62583/80 M R534
WITH THE OFFICER IN CHARGE OF CONTRACTS

December 1, 1980

GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

1980

SCEGIT-80-193

COMPUTER AIDED DESIGN

FOR MAF ENGINEERS

AN INVESTIGATION CONDUCTED BY
THE SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA

PROJECT DIRECTOR: D. W. HALPIN

PREPARED FOR

THE U. S. MARINE CORPS

UNDER PURCHASE ORDER N62583/80 M R534
WITH THE OFFICER IN CHARGE OF CONTRACTS
CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME, CALIFORNIA

DECEMBER 1, 1980

TABLE OF CONTENTS

FOREWARD

This report was prepared at Georgia Institute of Technology, Atlanta, Georgia by personnel of the Construction Management Program of the School of Civil Engineering for the U. S. Marine Corps, under a contract from the Naval Construction Battalion Center, Port Hueneme, California. The work was performed under the technical direction of Curtis Anderson, Project Engineer, CEL.

INTRODUCTION

The design methods utilized by engineers in the Marine Amphibious Force facilitate the development of computer aided design (CAD) systems since the design of expedient and more permanent facilities is based on parameters which are related to the final design by well defined procedures. Most of the required design procedures are clearly explained in a multitude of Army, Navy, and Marine Field and Technical Manuals. In a highly fluid battlefield situation the military engineer does not have the time to search out the various manuals to develop the required design. If the various military engineer design tasks were developed into a series of computer aided design software packages and stored in/with the unit's microcomputer, the MAF engineer would need only to call the desired application, provide the necessary input parameters, and in a matter of seconds receive a completed design. This completed design could be made in a hard copy form using either a matrix printer/plotter or a thermal printer and distributed to the implementing unit. The objective of this research is to study the existing level of development of MAF suitable design support systems and propose methods for implementing design support systems in the MAF mission situation.

Computer aided design effort for military construction applications lies mainly in the area of combat engineering, as designs for theater of operations facilities have already been standardized and prepared in the TM 5-300 series. Work on the development of computer aided designs for combat engineering applications initially began in the early 1970's at the U. S. Army Engineer Center, Fort Belvoir, Virginia, but was later discontinued as the computer technology had not sufficiently developed to provide a small rugged computer that could be used under field conditions. Recent developments in the microcomputer have revitalized the interest in the use of computer aided design for combat engineering applications.

Presently, the Army Engineer Center at Fort Belvoir is studying the possibilities of using small computers at the Battalion Field level. Additionally, some effort is being applied in the area of using programmable hand held calculators with preprogrammed magnetic cards to be used at company level and below. The most suitable level would probably be the squad or platoon. These magnetic tapes are preprogrammed to perform various design tasks so that the user need only insert the proper magnetic card, punch in the input parameters, and receive visual output. This implementation is excellent for determining logistical requirements and possible demolition placement design, but cannot provide the design for the majority of platoon and company level engineering missions.

This research will focus upon the use of the microcomputer as an aid to the MAF engineer in solving design problems related to military engineering within the Amphibious Operations Area (AOA). In the MAF, the implementing engineer element will probably be a battalion sized element. The use of computer aided designs at this level can facilitate the design process and enhance the capability of the small unit commander who is responsible for the engineering mission's success.

STUDY METHODOLOGY

In an effort to better understand the problems inherent in the design and development of Computer Aided Design systems for the MAF, several systems developed previously for combat engineering design tasks were identified and studied. Based on previous research at Civil Engineering Laboratory, Port Hueneme, the tasks that the military engineer is most likely to encounter in support of the MAF were found to be:

(1) Obstacle Fabrication and Installation/Positioning*

(2) Minefield Placement*

(3) Road Construction*

(4) Prefabricated Floating Bridge Erection

(5) Prefabricated Bridge Erection (Bailey)*

(6) Timber Bridge Erection*

(7) Raft Construction and Operations*

(8) Expeditionary Airfield Construction

(9) Helicopter Landing Site and Zone Preparation

(10) Potable Water Supply Installation

(11) Hygenic Services Installation

(12) Electrical Service Installation

(13) Camp Construction

(14) Fuel Storage Distribution System Construction

An investigation of these applications revealed that programs to perform many of these tasks have been previously prepared by the U. S. Army Engineer School, Fort Belvoir, Virginia, and are presently being implemented by the 20th Engineer Brigade (Combat) Airborne, Fort Bragg, N. C. Engineer tasks for which prototype programs have been identified are indicated by an asterisk (*).

In addition, a microcomputer implementation of a water point selection program has been identified and provided interesting insights into the possible implementation of an interactive program with graphics capability. This program was developed as a Masters Thesis project by Captain Monty J. Anderson, USA, at Georgia Institute of Technology. The title of the masters thesis report is "A Prototype Decision Support System for the location of Military Water Points." The methodology developed in this thesis is also applicable to the Fuel Storage and Electrical Service tasks listed above. This report will be discussed in a later section.

In addition to the study of existing systems, prototype systems for the Prefabricated Floating Bridge Erection and Helicopter Landing Site and Zone Preparation tasks were developed. These systems were developed to better understand the problems involved in design and implementation of design oriented systems for use in the combat zone. The following sections briefly describe existing systems which were studied. Discussions of the systems developed within the scope of this research are then discussed. The final sections cover conclusions regarding the design and implementation of an optimal Computer Aided Design system for the MAF.

SYSTEMS FOR OBSTACLE PLANNING INSTALLATION

An obstacle planning program has been designed which provides a rapid planning estimate for barrier construction at the MAF level. The obstacles coordinated by the system include:

(1) Standard pattern minefields
(2) Wire entanglements
(3) Anti-vehicular ditches
(4) Log cribs
(5) Log/Steel/Concrete posts
(6) Abatis

The program is designed to calculate troop effort, equipment and materials for individual obstacles and the total barrier based on a one to four priority of obstacles.

The obstacle program (OBSTAC) utilizes the following material/resources;

(1) Pickets Long
(2) Pickets Medium
(3) Pickets Short
(4) Barbed Wire (400 M Reel)
(5) Barbed Tape (300 M Reel)
(6) Barbed Wire (Concertina)
(7) Barbed Tape (Concertina)
(8) Staple
(9) GP Barbed Tape Obstacle
(10) TNT (LBS)
(11) Cratering Charges (40 lbs)
(12) Shaped Charge
(13) 10' Log Post
(14) 7' Log Post
(15) 10' Concrete Post
(16) 9" Steel Post
(17) M15 Hvy at Mine (MET)
(18) M19 Hvy at Mine (NM)
(19) M21 Killer at Mine
(20) M16A1 AP Frag Mine
(21) M26 AP Frag Mine
(22) M3 AP Frag Mine
(23) M14 AP Blast Mine
(24) M25 AP Blast Mine
(25) M18A1 AP Frag (Claymore)
(26) M49A1 Tripflare
(27) Engineer Tape (Roll)
(28) Anti-Handling Devices

The program utilizes the following equipment and manpower resources:

(1) 2-½T Cargo Truckloads
(2) 1-½T Cargo Trailerloads
(3) 5T Dump Truckloads
(4) Squad Hours
(5) Angle Dozer Hours
(6) Platoon Hours
(7) Pile Driver Hours
(8) Earth Auger Hours
(9) Backhoe Hours
(10) Grader Hours

Additional resources considered by the Program include:

(1) Wall/Hurdle Log (Road Width)
(2) 7' Log Diag Brace
(3) M24/M66 Off Route Mine
(4) M23/M1 Chem Mine
(5) Minefield Signs
(6) Sandbags

The OBSTAC program will evaluate any number of barrier plans. The overall plan and individual obstacles in each plan can be assigned a priority of 1 to 4.

Specific obstacles and input required for each obstacle are as given below:

A. Minefields:

(1) This program will analyze and compute requirements for a standard pattern minefield.

(2) Inputs:

(a) Minefield Density i.e., 1, 2, 2.
(b) IOE Representative Cluster
(c) Minefield Front in Meters
(d) Minefield Depth in Meters
(e) Percent Anti-Handling Devices
(f) At Mine Type: M-15, M-19, M-21
(g) APF Mine Type: M16A1, M26, M3

(h) APB Mine Type: M-14, M-25

(i) Obstacle Priority

(j) Type Truck for Mine Haul: 2½T Cargo, 1½T Trailer, 5 Ton Dump

(k) Will Trucks be overloaded

(3) Outputs

(a) Minefield requirements

(b) Cluster composition table

(4) A sample of the input/output of the Minefield portion of the OBSTAC program would appear as follows:

Standard Pattern Minefield

INPUT

Minefield Density	(1, 2, 4)
IOE Representative Cluster	(1, 0, 2)
Minefield Front in Meters	(300)
Minefield Dept in Meters	(100)
Percent Anti-Handling Devices	(20)
At Mine Type: M-15, M-19, M-21	(M-19)
APF Mine Type: M16A1, M26, M3	(M-16A1)
APF Mine Type: M-14, M-25	(M-14)
Obstacle Priority	(1)
Type Truck for Mine Haul	(5 Ton Dump)
Will Trucks be Overloaded	(no)

OUTPUT

DETAILED REQUIREMENTS FOR MINEFIELD (PRIORITY 1) IN PLAN 1

RESOURCE	AMOUNT REQ.
Platoon Hours	11
Pickets Medium	90
Barbed Wire (400 M Reel)	7
St Dump Truckloads	4.10969387755
M19 Hvy at mine (NM)	368
M16A1 AP Frac Mine	660
M14 AP Blast Mine	1395
Minefield Signs	90
Engineer Tape (Roll)	33
Sandbags	1632
Anti-Handling Devices	74

SUGGESTED CLUSTER COMPOSTION TABLE

	AT	APF	APB
IOE Cluster Comp	1	0	2
Main Field Density	1	2	4

STRIP	AT	APF	APB	TOTAL
	1	1	3	5
	0	2	2	4
	1	1	2	4
	0	1	3	4
	1	1	2	4
TOTALS	3	6	12	0

B. Wire Entanglements:

(1) The program will analyze requirements for the following wire entanglements:

(a) Double Apron Fence - 4 & 2 pace

(b) Double Apron Fence - 6 & 3 pace

(c) High Wire

(d) Low Wire 4 & 2 pace

(e) 4 Strand Cattle Fence

(f) Triple Standard Concerntina

(g) GP Barbed Tape Obstacles

(2) Inputs:

(a) Type Deployment:

1 Conventional Linear Deployment

2 Base Camp Defense

(b) Frontage or perimeter in meters:

(c) Obstacle Use:

1 Tactical

2 Protective

3 Supplementing (Base Camp or Forward of FEBA).

4 Supplementary (Rear of FEBA).

(d) Number of Belts/Rows

(e) Picket Type:

1 Screw

2 "U" Shaped

3 Wooden

(f) Day or Night Construction

(g) Experienced or Inexperienced Troops.

(h) Obstacle Priority

(i) Will barbed tape or barbed concentina be used instead of barbed wire/concentina?

(3) Outputs: Program outputs materials, manhours, and equipment required for each wire obstacle.

(4) Typical input and output for the Wire Entanglements program (Triple Standard Concertina) are as follows:

INPUTS

Base Camp Defense

Frontage or Perimeter in Meters (1000)

Obstacle Use (Supplemental - Base Camp or Forward for FEBA)

Number of Rows (2)

Picket Type ("U" Shaped)

Day Construction

Inexperienced Troops

Obstacle Priority (1)

Barbed Tape/Concertinas (Not Used)

OUTPUT

DETAILED REQUIREMENTS FOR WIRE OBSTACLE
(PRIORITY 1) IN PLAN 1

RESOURCE	AMT. REQ.
Pickets Long	1328
Pickets Short	34
Barbed Wire (400 M Reel)	25
Barbed Wire (Concertina)	490
Staple	2632
St Dump Truckloads	9.038800705467
Squad Hours	24.9

*** U-Shaped Pickets are used ***

C. Log Cribs:

(1) The program will analyze requirements for the following types of log crib obstacles:

(a) Rectangular, Posts Opposing

(b) Rectangular, Posts Offset

(c) Triangular

(d) Supplemental 3 Log Hurdles

(2) Inputs:

(a) Obstacle Priority

(b) Roadway Width in feet

(c) Diameter of Wall Logs in Inches

(d) Troop Experience

<u>1</u> Skilled

<u>2</u> Average

<u>3</u> Slow

(e) Is Log Crib to be augmented with Log Hurdle?

(3) Output: Program outputs materials, manhours, and equipment required for each log crib.

(4) Typical input and output for the Log Crib Program are as shown below:

<u>INPUT</u>

Obstacle Priority (3)

Roadway Width in Feet (60)

Diameter of Wall Logs in Inches (10)

Troop Experience (Average)

Is Log Crib to be Augmented with Log Hurdle? (Yes)

OUTPUT

DETAILED REQUIREMENTS FOR LOG CRIB

PRIORTY 3, IN PLAN 1

RESOURCE	AMT. REQ.
10' Log Post	42
7' Log Post	11
7' Log Diag. Brace	21
Wall/Hurdle Log (Road Width)	19
St Dump Truckloads	2.71875
Platoon Hours	27

*** NOTES ***

This obstacle includes a log Hurdle

You may wish to use wire rope to strengthen your obstacle

All Logs are minimum 8 in (20 CM) Diameter

D. Log/Steel/Concrete Post Obstacles:

(1) Inputs:

(a) Type of Obstacle:

1 Concrete
2 Steel
3 Wood

(b) Obstacle Priority

(c) Obstacle Front in meters

(d) Post Spacing (1 Meter minimum - 2 meters maximum)

(e) Troop Experience:

1 Skilled
2 Average
3 Slow

(f) Day or Night Installation

(g) Number of Rows (4 minimum, 8 maximum)

(h) Construction Method

1 Pile Driver

2 Earth Auger

3 Shape Charges

4 Hand Tools

(2) Output: Program outputs materials, manhours, and equipment hours required for each obstacle.

(3) Typical input and output for the Log/Steel/Concrete post obstacle program appear as shown below:

INPUT

Type Obstacle (Wood)

Obstacle Priority (4)

Obstacle Front in Meters (200)

Post Spacing (1.5 Meters)

Troop Experience (Average)

Night Installation

Number of Rows (5)

Construction Method (Earth Auger)

OUTPUT

DETAILED REQUIREMENTS FOR LOG POST OBSTACLE
(PRIORITY 4), PLAN 1

RESOURCE	AMT. REQ.
10' Log Post	667
51 Dump Truckloads	41.6875
Squad Hours	140.625
Earth Auger Hours	140.625

E. Anti-Vehicular Ditches:

(1) The program will analyze requirements for the following types of Anti-Vehicular Ditches.

(a) Trangular

(b) Sidehill

(c) Trapezoidal

(2) Inputs:

(a) Type of Ditch:

1 Triangular

2 Sidehill

3 Trapezoidal

(b) Construction Method

1 Hand Excavation

2 Explosives

3 Machine

a 1 Dozer

2 Backhoe

b 1 Dress Walls w/Grader

2 Dress Walls w/Handtools

3 Do Not Dress Walls

(c) Ditch length in meters

(d) Day or Night Construction

(e) Experienced Troops (yes/no)

(f) Obstacle Priority

(3) Output: Program outputs material, manpower, and equipment time to construct ditch. In addition it will also print a profile sketch with dimensions and notes.

(4) Typical input and output for the Anti Vehicular Ditches program are as shown below:

INPUT

Type of Ditch (TRAPE 201 DAL)
Construction Method Machine
  Dozer
  Dress Walls with Grader
Ditch Length in Meters (200)
Day Construction
Experienced Troop (yes/no) (Yes)
Obstacle Priority (2)

OUTPUT

DETAILED REQUIREMENTS FOR DITCH
PRIORTY 2, PLAN 1

RESOURCE	AMT. REQ.
Wall/Hurdle Log (Road Width)	6
Grader Hours	19.14285714286
Angle Dozer Hours	19.14285714286
Squad Hours	19.14285714286

A Log Hurdle has been added to this ditch

DESIRED DITCH PROFILE
TRAPEZOIDAL DITCH

```
           ..
        ..:..                                             HURDLES
      ..SPOIL.
     ............  ------ W1 ------  -4.5M--o0o ---7.5M----o0o
******************                 *********************
                  *               **
                   *             *
                    **********
                    ---W2----
```

H = 1.8 M
W1 = 4.0 M   FRIENDLY SIDE REVETTED IF POSSIBLE
W2 = 2.0 to 3.0 M

F. Abatis:

(1) Inputs:

(a) Mean tree diameter in inches and depth of target in meters (24,100).

(b) Method of Construction:

<u>a</u> Demolitions

<u>b</u> Squad w/chain saw

c Squad w/hand tools

d Platoon w/hand tools

(c) Day or Night Construction

(d) Experienced Troops (yes/no)

(e) Obstacle Priority.

(2) Outputs: Program outputs material, manpower, and equipment to construct abatis.

(3) Typical input and output for the Abati program are shown below:

<u>INPUT</u>

Output: Program outputs materials manpower, and equipment time to construct ditch. In addition it will also print a profile sketch w/ dimensions and notes.

Abatis:

Inputs:

Mean tree diameter in inches and depth of target in meters (30,75)

Method of Construction (Demolitions).

Day or Night Construction (Night)

Experienced Troops (yes/no) (yes)

Obstacle Priority (2)

OUTPUT

DETAILED REQUIREMENTS FOR ABATIS OBSTACLE
PRIORITY 2, IN PLAN 1

RESOURCE	AMT. REQ.
Pounds of TNT	1388
Squad Moves	3.78

You may wish to consider trying the trees together with wire. Try 18 lbs TNT rounded to the next closest package size, for your test shot.

G. Obstacle Plan Recap Program Output:

After each individual obstacle has been evaluated, the program provides a recapitulation of materials, manpower, and equipment hours for all obstacles by construction priority and the total plan. This recap allows the planner to evaluate required and available resources on both a construction priority and total plan basis.

PLAN 1
REQUIREMENTS FOR PRIORITY 1 OBSTACLES
THIS PRIORITY CONTAINS 2 OBSTACLE(S)

RESOURCE	AMT. REQ.
Pickets Long	1328
Pickets Medium	90
Pickets Short	34
Barbed Wire (400 M Reel)	32
Barbed Wire (Concertina)	490
Staple	2632
St Dump Truckloads	13.14849458301
Squad Hours	24.9
M19 HVY at Mine (NM)	11

Resource	Amt. Req.
M19 HVY At Mine (NM)	368
M16A1 AP Frag Mine	660
M14 AP Blast Mine	1395
Minefield Signs	90
Engineer Tape (Roll)	33
Sandbags	1632
Anti-Handling Devices	74

REQUIREMENTS FOR PRIORITY 2 OBSTACLES

THIS PRIORITY CONTAINS 2 OBSTACLE(S)

Resource	Amt. Req.
Lbs TNT	1388
Shaped Charge	19.14285/14286
Wall/Hurdle Loc (Road Width)	6
Angle Dozer Hours	19.14285/14286
Squad Hours	22.92285714286

REQUIREMENTS FOR PRIORITY 3 OBSTACLES

THIS PRIORITY CONTAINS 1 OBSTACLE(S)

Resource	Amt. Req.
10' Log Post	42
7' Log Post	11
7' Log Diag Brace	27
Wall/Hurdle Log(Road Width)	13
St Dump Truckloads	2.71875
Platoon Hours	27

REQUIREMENTS FOR PRIORITY 4 OBSTACLES

THIS PRIORITY CONTAINS 1 OBSTACLE(S)

RESOURCE	AMT. REQ.
10' Log Post	667
St Dump Truckloads	41.6875
Squad Hours	140.625
Earth Auger Hours	140.625

SYSTEMS FOR THE DESIGN OF ROADS

A program tailored to the requirements of the MAF engineer planner and designer for the design of roads and Main Supply Routes (MSR) has been developed. This multipurpose earthwork estimating and design assistance program performs the following tasks for 1000 meters and 10 meter intervals/stations.

(a) Generates a centerline profile and computes slope between topographical evaluations or design grade stations either singly or superimposed on each other. (See Figure 1).

(b) Computes cut-fill end areas at each 10 meter station in a 1000 meter segment of interest given the topographic and design elevations at the centerline and each edge.

(c) Computes volume of cut and fill between the stations. Adjusts these quantities for stripping loss.

(d) Computes the elevation and distance from centerline of the right and left toe at each station. (The toe is the point of intersection of the cut/fill slope and the existing terrain).

(e) Computes the square meters of stripping required to clear the right of way from toe to toe.

(f) Computes the loose cubic yards of stripping/burden which must be cleared from right of way.

(g) Plots a mass diagram to the same horizontal scale as the center line plot. (See Figure 2)

(h) Elevation and Earthwork Estimate data list as follows:

FIGURE 1 (a)

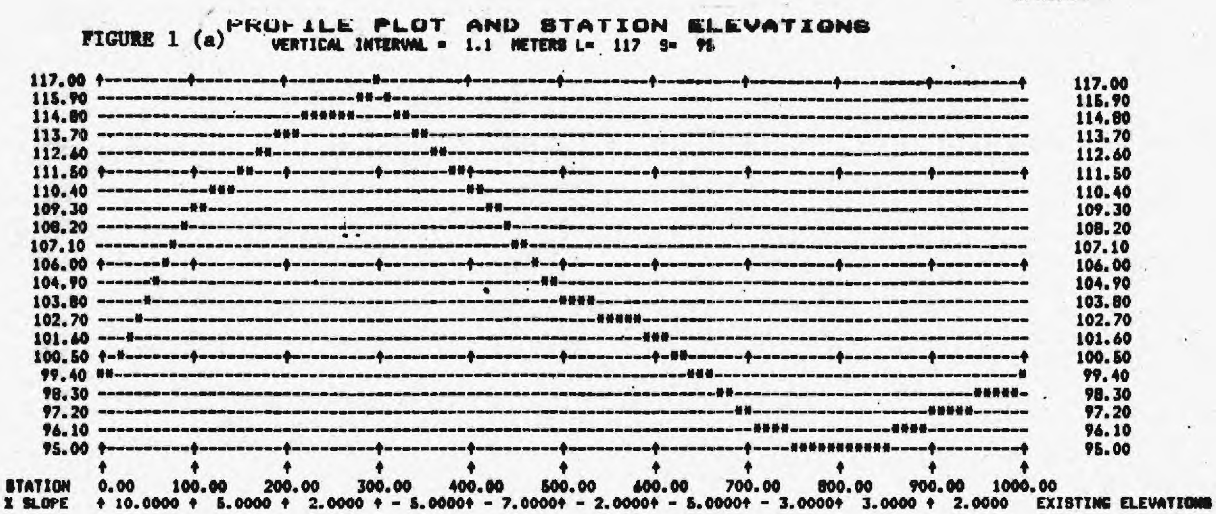


FIGURE 1 (b)

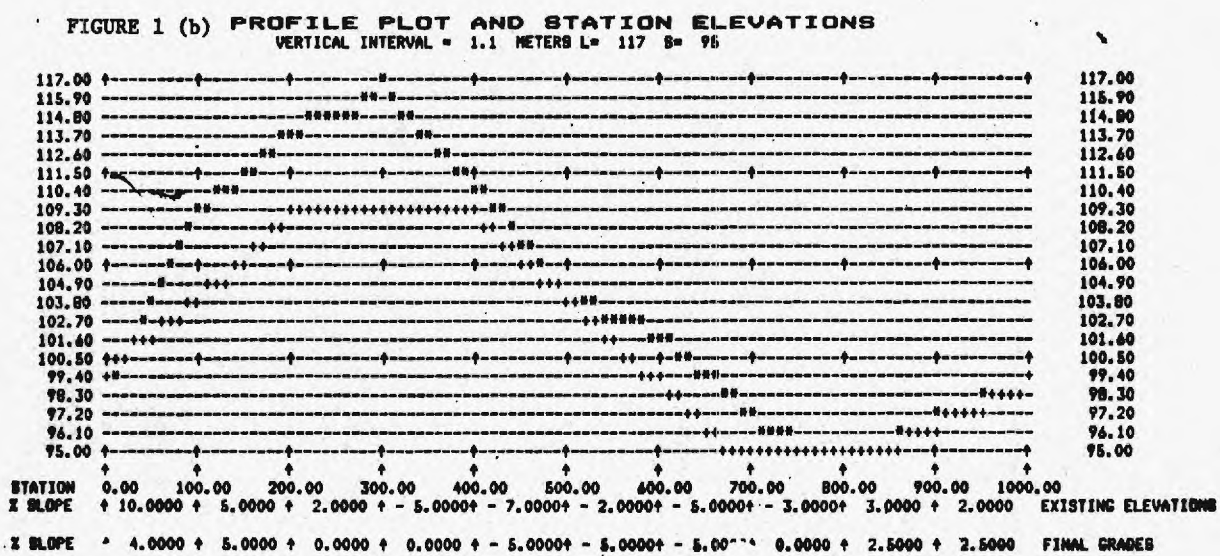
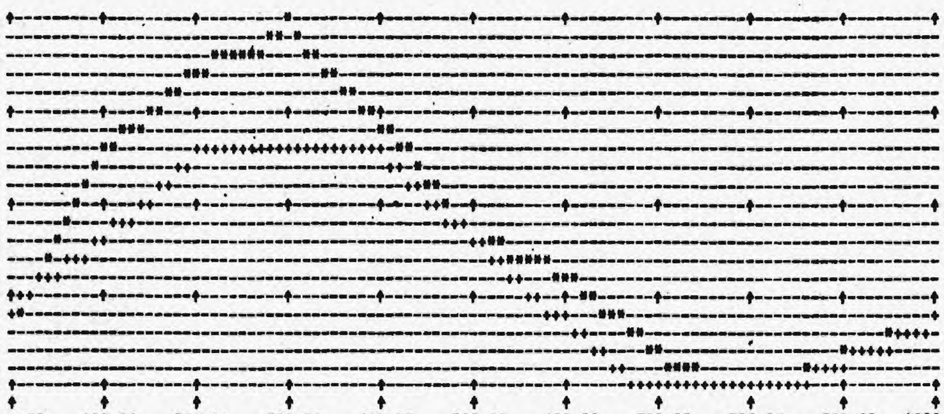


FIGURE 1: PROFILE PLOT AND STATION ELEVATIONS

FIGURE 2(a) PROFILE PLOT AND STATION ELEVATIONS

VERTICAL INTERVAL = 1.1 METERS L= 117 S= 95

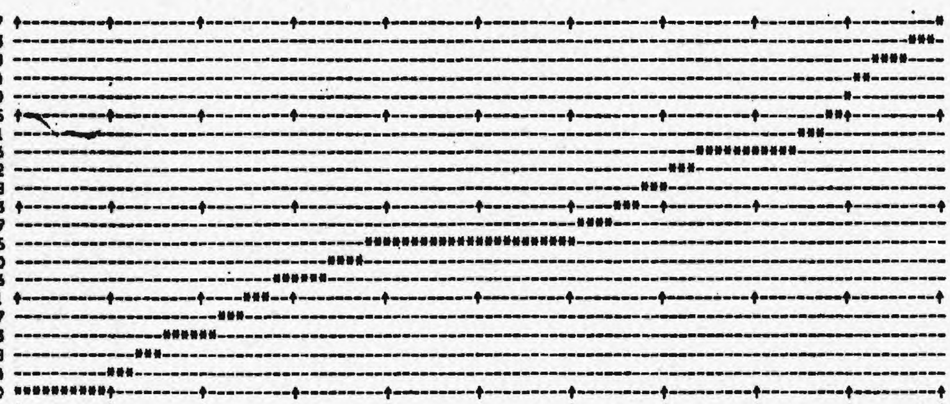


% SLOPE + 10.0000 + 5.0000 + 2.0000 + - 5.0000+ - 7.0000+ - 2.0000+ - 5.0000+ - 3.0000+ 3.0000 + 2.0000 EXISTING ELEVATIONS

% SLOPE + 4.0000 + 5.0000 + 0.0000 + 0.0000 + - 5.0000+ - 5.0000+ - 5.0000+ 0.0000 + 2.5000 + 2.5000 FINAL GRADE +++

FIGURE 2(b) MASS DIAGRAM

VERTICAL INTERVAL = 1842.34 LOOSE CUBIC METERS



VOLUME 0.00 + 7910.45 + 16625.63 + 17203.53 + 26141.76 + 36846.88 +

3326.21 12739.69 16427.45 22767.81 30941.92

INITIAL VOLUME IS 0 LOOSE CUBIC METERS

RIGHT OF WAY STRIPPING 26510.23 SQUARE METERS

ENDING V[illegible]ME IS 36846.88 LOOSE CUBIC METERS

STRIPPING VOLUME IS 5050.2 LOOSE CUBIC METERS

This list gives the elevations of the centerline and left and right shoulders of both the existing terrain and the design grade, the end area cut and fill, the inplace cut and fill volume in cubic meters between each station adjusted for stripping loss, and the mass balance in loose cubic meters adjusted for stripping loss. (Table 1)

The problem is defined to the program using the following input:

- Enter centerline and edge elevations for both the topographic and design grades. Three options are available for entering the data:

  (a) Centerline and edges equal-input centerline elevation and distance from centerline to edges. Computer places edge elevations equal to the centerline elevations.

  (b) Enter centerline and compute edges-enter centerline elevations, distance to edge (in meters) and percent slope from centerline to edge. Computer computes edge elevations. Both left and right edge must be equidistant from centerline and have the same slope.

  (c) Enter centerline and Edges - the centerline and edge elevations for the 100 meter stations are entered individually. The distance in meters from the centerline to the edges is entered.

- Enter the percent slope from the edge of final grade to the existing topographic (toe) for a fill and cut section.

TABLE 1: **ELEVATION AND EARTHWORK ESTIMATE DATA**

STATION 0 TO STATION 1000

	EXISTING ELEVATION			FINAL GRADE			END AREAS		VOLUME(TO STA)			
STATION	LEFT	CENTER	RIGHT	LEFT	CENTER	RIGHT	CUT	FILL	CUT	FILL	MASS (LCM)	STATION
0.00	101.00	100.00	102.00	100.00	101.00	100.00	9.16	2.12	0.00	0.00	0.00	0.00
10.00	101.30	101.00	102.40	100.20	101.20	100.20	12.89	5.17	73.09	35.05	36.58	10.00
20.00	101.60	102.00	102.80	100.40	101.40	100.40	27.82	0.00	177.35	14.18	213.93	20.00
30.00	101.90	103.00	103.20	100.60	101.60	100.60	37.71	0.00	291.40	0.00	534.48	30.00
40.00	102.20	104.00	103.60	100.80	101.80	100.80	47.59	0.00	390.20	0.00	963.70	40.00
50.00	102.50	105.00	104.00	101.00	102.00	101.00	57.49	0.00	489.02	0.00	1501.62	50.00
60.00	102.80	106.00	104.40	101.20	102.20	101.20	67.38	0.00	587.87	0.00	2148.29	60.00
70.00	103.10	107.00	104.80	101.40	102.40	101.40	77.27	0.00	686.74	0.00	2903.70	70.00
80.00	103.40	108.00	105.20	101.60	102.60	101.60	87.17	0.00	785.62	0.00	3767.89	80.00
90.00	103.70	109.00	105.60	101.80	102.80	101.80	97.06	0.00	884.52	0.00	4740.88	90.00
100.00	104.00	110.00	106.00	102.00	103.00	102.00	106.96	0.00	983.44	0.00	5822.66	100.00
110.00	104.20	110.50	106.60	102.20	103.20	102.20	113.19	0.00	1063.81	0.00	6992.87	110.00
120.00	104.40	111.00	107.20	102.40	103.40	102.40	119.55	0.00	1126.32	0.00	8231.82	120.00
130.00	104.60	111.50	107.80	102.60	103.60	102.60	126.05	0.00	1190.18	0.00	9541.02	130.00
140.00	104.80	112.00	108.40	102.80	103.80	102.80	132.69	0.00	1255.42	0.00	10921.99	140.00
150.00	105.00	112.50	109.00	103.00	104.00	103.00	139.47	0.00	1322.08	0.00	12376.27	150.00
160.00	105.20	113.00	109.60	103.20	104.20	103.20	146.40	0.00	1390.18	0.00	13905.48	160.00
170.00	105.40	113.50	110.20	103.40	104.40	103.40	153.48	0.00	1459.76	0.00	15511.22	170.00
180.00	105.60	114.00	110.80	103.60	104.60	103.60	160.72	0.00	1530.85	0.00	17195.16	180.00
190.00	105.80	114.50	111.40	103.80	104.80	103.80	168.11	0.00	1603.49	0.00	18959.00	190.00
200.00	106.00	115.00	112.00	104.00	105.00	104.00	175.66	0.00	1677.70	0.00	20804.48	200.00
210.00	106.60	115.20	111.50	104.10	105.10	104.10	172.16	0.00	1698.05	0.00	22672.34	210.00
220.00	107.20	115.40	111.00	104.20	105.20	104.20	169.52	0.00	1667.99	0.00	24507.14	220.00
230.00	107.80	115.60	110.50	104.30	105.30	104.30	167.66	0.00	1646.02	0.00	26317.77	230.00
240.00	108.40	115.80	110.00	104.40	105.40	104.40	166.52	0.00	1631.39	0.00	28112.30	240.00
250.00	109.00	116.00	109.50	104.50	105.50	104.50	166.03	0.00	1623.50	0.00	29898.16	250.00
260.00	109.60	116.20	109.00	104.60	105.60	104.60	166.15	0.00	1621.89	0.00	31682.25	260.00
270.00	110.20	116.40	108.50	104.70	105.70	104.70	166.86	0.00	1626.21	0.00	33471.08	270.00
280.00	110.80	116.60	108.00	104.80	105.80	104.80	168.14	0.00	1636.18	0.00	35270.88	280.00
290.00	111.40	116.80	107.50	104.90	105.90	104.90	169.96	0.00	1651.64	0.00	37087.69	290.00
300.00	112.00	117.00	107.00	105.00	106.00	105.00	172.33	0.00	1672.47	0.00	38927.41	300.00
310.00	111.80	116.50	107.20	105.00	106.00	105.00	166.98	0.00	1657.38	0.00	40750.53	310.00
320.00	111.60	116.00	107.40	105.00	106.00	105.00	161.67	0.00	1603.92	0.00	42514.85	320.00
330.00	111.40	115.50	107.60	105.00	106.00	105.00	156.41	0.00	1550.91	0.00	44220.85	330.00
340.00	111.20	115.00	107.80	105.00	106.00	105.00	151.20	0.00	1498.38	0.00	45869.08	340.00
350.00	111.00	114.50	108.00	105.00	106.00	105.00	146.06	0.00	1446.41	0.00	47460.14	350.00
360.00	110.80	114.00	108.20	105.00	106.00	105.00	140.98	0.00	1395.07	0.00	48994.72	360.00
370.00	110.60	113.50	108.40	105.00	106.00	105.00	135.98	0.00	1344.43	0.00	50473.60	370.00
380.00	110.40	113.00	108.60	105.00	106.00	105.00	131.07	0.00	1294.59	0.00	51897.66	380.00
390.00	110.20	112.50	108.80	105.00	106.00	105.00	126.26	0.00	1245.68	0.00	53267.91	390.00
400.00	110.00	112.00	109.00	105.00	106.00	105.00	121.57	0.00	1197.82	0.00	54585.52	400.00
410.00	109.60	111.30	108.10	105.00	106.00	105.00	104.18	0.00	1087.98	0.00	55782.30	410.00
420.00	109.20	110.60	107.20	105.00	106.00	105.00	87.54	0.00	919.30	0.00	56793.53	420.00
430.00	108.80	109.90	106.30	105.00	106.00	105.00	71.62	0.00	757.96	0.00	57627.30	430.00
440.00	108.40	109.20	105.40	105.00	106.00	105.00	56.40	0.00	603.74	0.00	58291.41	440.00
450.00	108.00	108.50	104.50	105.00	106.00	105.00	42.20	0.62	448.32	1.18	58783.09	450.00
460.00	107.60	107.80	103.60	105.00	106.00	105.00	30.37	4.75	323.86	23.79	59109.60	460.00
470.00	107.20	107.10	102.70	105.00	106.00	105.00	20.72	12.50	214.77	83.37	59241.63	470.00
480.00	106.80	106.40	101.80	105.00	106.00	105.00	12.90	23.70	125.52	178.22	59156.92	480.00
490.00	106.40	105.70	100.90	105.00	106.00	105.00	6.81	38.42	53.34	307.36	58831.38	490.00
500.00	106.00	105.00	100.00	105.00	106.00	105.00	3.05	57.50	1.56	476.16	58237.89	500.00
STATION	LEFT	CENTER	RIGHT	LEFT	CENTER	RIGHT	CUT	FILL	CUT	FILL	MASS (LCM)	STATION

- Enter the average depth for stripping in meters.
- Enter the compaction factors for the soil:
  (a) In place to loose
  (b) Loose to compact
- Enter the initial mass balance in loose cubic meters.
- Enter the output dimension of the profile plot (feet or meters).

OBSTACLE CROSSING DESIGN SUPPORT PROGRAMS

Five programs relating to the MAF engineer tasks (5), (6) and (7) listed above were identified. These programs are as:

(1) Bailey Bridge Program

(2) Stringer Design Program

(3) Bridge Superstructure Program

(4) Bridge Classification Program

(5) Rafting Program

This section gives a brief description of the input and output date required by and developed by these programs. Listings of these programs are available on request.

The Bailey Bridge Design program computes the type of Bailey configuration required and its installation time given the gap width, bank elevations, soil conditions and required load class. The design procedures used are based on TM 5-277. The design assumes that (a) bridge launch will be level and (b) single span will be satisfactory. The required input is as follows:

Near shore abutment: prepared or unprepared

Far shore abutment: prepared or unprepared

Gap in feet

Bank height in feet: near shore, far shore

Weight class requirement: wheeled, tracked

Soil bearing capacity: tons/sq. foot

The output is as follows:

Gap ____ feet

Condition of abutments	Near Shore _____	Far Shore _____
Bank height	Near Shore _____	Far Shore _____
Bridge classification	Wheeled ________	Tracked _______
Abutment soil bearing capacities	Near Shore _____	Far Shore _____
Safety setback requirements (ft)	Near Shore _____	Far Shore _____
Truss type required		
Grillage type	Near Shore _____	Far Shore _____
Rocking rollers	Near Shore _____	Far Shore_____
Roller clearance	Near Shore _____	Far Shore _____
Plain rollers (No. of Rows)	Near Shore _____	Far Shore _____

Number of jacks required at each end

Number of bays in lauching nose: Single Single

Double Single

Dougle Double

Placement of lift link _____ Feet from the tip of lauching nose

Construction distance required behind rocking rollers _____feet

Number of bays with decking and stringers

Number of bays omitted in top story

Bays of initial construction

Lauching nose sag ____ inches

Construction personnel required NCO_____

EM _____

Construction time _____hours

The Stringer Design Program is developed to aid in the design of timber trestle bridges and is based upon the design criteria in TM 5-312. The input is as follows:

Roadway width (feet)

Bridge deck total width (feet)

Span length - maximum 60 feet

Number of stringer available

Stringer spacing (feet)

Type of stringer desired

(1) Wood (rectangular or round)

(2) Steel

Bridge classification	wheel	one way	two way
	tracked	" "	" "

The output from the Stringer Design Program is as follows:

Maximum unsupported length

Total moment and shear capacity of stringers

Dead Load

Live Load

Required number of stringers

Required number of lateral bracing

Shear (tons)

Stringer type

Flange width, beam height, flange thickness, web thickness

The subroutine to develop Superstructure Classification requires the following input:

Type of decking (1) Plank

(2) Laminated

What percent lamination (decimal)

Deck thickness (inches)

Wearing surface (1) Timber

(2) Asphalt, concrete, masonry

Condition of bridge component 1 = Good

2 = Other

Width in feet

The program calculates and prints the bridge deck classification for wheeled and tracked vehicles.

The Bridge Classification Program prints out a total classification for a given bridge given the appropriate input information. The Stringer Design, Superstructure Classification, and Bridge Classification Programs are interrelated and must be run concurrently to design a bridge or classify an existing structure. The input required for the Bridge Classification Program is as follows:

Type of stringer, wood or steel

Stringer spacing

Flange thickness (output from stringer design program)

Web thickness (" " " " ")

Deck thickness

Wearing surface thickness

One or two lanes

Roadway width

End bearing size for stringer

Output from the Bridge Classification Program includes:

Bridge dead load

Table of bridge width restrictions

Table of bridge width classifications

Weight of wearing surface (lb/ft)

Weight of stringer (lb/ft)

Bridge deck width

Bridge classification

Wheeled Tracked One Way Two Way

The Rafting Program computes the raft types, raft loads, and the quanity of vehicles crossing at a rafting site. The program uses a data file for a predetermined unit. This data file is developed prior to the raft design and updated daily so that accurate crossing information can be used. Within the data file the vehicle type, priority class, length, and quanity to cross the river is stored. The input to the program is as follows:

Data file

Unit designations

River width, speed, trip time, raft site, unit size, no. of vehicles per unit

Weather conditions (good or bad)

Time of day (day or night)

Width of river at each site (meters)

Speed of river at each site (feet/second)

Type rafts to be used

Number of rafting sites (maximum of 5)

Number of units/site (maximum of 4)

Number of vehicles/unit (maximum of 50 vehicles/unit)

Type of the following rafts to be used:

LTR	4 pontons 3 bays
	5 pontons 3 bays
	6 pontons 4 bays
M4T6	4 normal floats
	4 reinforced floats
	5 normal floats
	5 reinforced floats
MAB	2 ramp bays
	1 interior 2 ramps
	2 interiors 2 ramps
	3 interiors 2 ramps
	4 interiors 2 ramps
Ribbon	3 bays
	4 bays
	5 bays

Will construction of all rafts begin at the same time? (yes, no)

Time to begin construction?

The program output provides the following information to the user:

List of vehicles for each unit in sequence giving priority and class (High priority vehicles are to be loaded first).

Site, unit, raft type, load class, vehicle #, vehicle type

Operation complete at ______ time

Number of vehicles H plus ______ time

This program could be enhanced by allowing the computer to calculate the trip time for the crossing rafts. This could be accomplished by adding an additional data file and a few statements within the program. By adding this enhancement, the engineer would be required to make no calculations but would only have to provide river and rafting considerations. The data file can be obtained from the information given on page 14 of the "Planning Guide for the use of U. S. Army Floating Equipment" published in Spring 1979, by the U. S. Army Engineer School, Fort Belvoir, Va.

INTERACTIVE GRAPHICS PROGRAM

The programs discussed in the previous sections utilize a structured input based on existing Technical Manual procedures and develop a structured output to establish the basis for mission design and field order issuance. Some of the problems encountered in the MAF are not as rigidly structured and require an interaction between the designer and the computer. One class of problems which fall into this category is referred to as location allocation problems. Anderson describes this type of problem as follows:

> "Problems of this nature involve the placement of one or more sources which will be used to satisfy, in an optimum manner, demands at various destinations. What must be determined is the location of the sources and the distribution or allocation of the commodity so that the destinations are supplied most economically."

All problems which relate to resupply operations fall into this category in one aspect of their solution. In the MAF, the location of Water Points and Fuel Supply Points and the units to be serviced by the established points is a typical location-allocation problem. These problems are open ended and start with the evaluation of possible supply point location and end with the assignment of customer units to the selected supply points. Material in the following sections of this chapter is excerpted directly from Anderson's Masters thesis.

This problem is ideally suited to solution in a microcomputer environment in which the MAF engineer interfaces with the problem using a high resolution graphics terminal. Input to the computer using a bit pad which digitizes input information submitted in a graphical form consists of the definition of the road network which links service points with the units being serviced. This information together with supported unit demands and the selected sources with their associated supply volume (i.e. quantity) allow the computer to make a shortest path calculation to determine what serviced units should be served from which supply points. The methodology is described by Anderson as follows in the context of the water supply point location problem:

"The solution method implemented is:

(1) Data input by user and machine:

Network (I,J), distances (d_{ij}) and potential combat unit and water point locations.

(2) Specification by user of supported unit demands (b_{ij})

(3) Selection by user of the number of open sources (y_{ij}) and their respective supplies (q_{ij})

(4) Shortest path solution by machine: Cost (c_j)

(5) Transportation solution by machine: Flows (x_{ij}) and total cost Z.

(6) Presentation by machine of solution quality indicators: loading of each source $\sum_i x_{ij}$ vs q_i, allocation of costs per unit of flow over the water points $\sum_j x_{ij} c_{ij} / \sum_i x_{ij}$, total distances traveled by demand points $\sum_j x_{ij} c_{ij}$ and alternative costs for each demand point.

(7) Decision by user: Return to either (1), (2), (3) or stop. "

A flow chart for user actions is shown in Fig. 3.

"The first step is the preparation of an initial data base. The road network in the area of concern is identified and input using the digitizer pad. All potential, but not necessarily utilized, supported unit locations and water point locations are entered as nodes on the network.

"The second step is specification by the user of the estimated demand for each supported unit. For each unit a personnel strength is entered. A demand is computed and then transformed to an integer number of trips that the supported

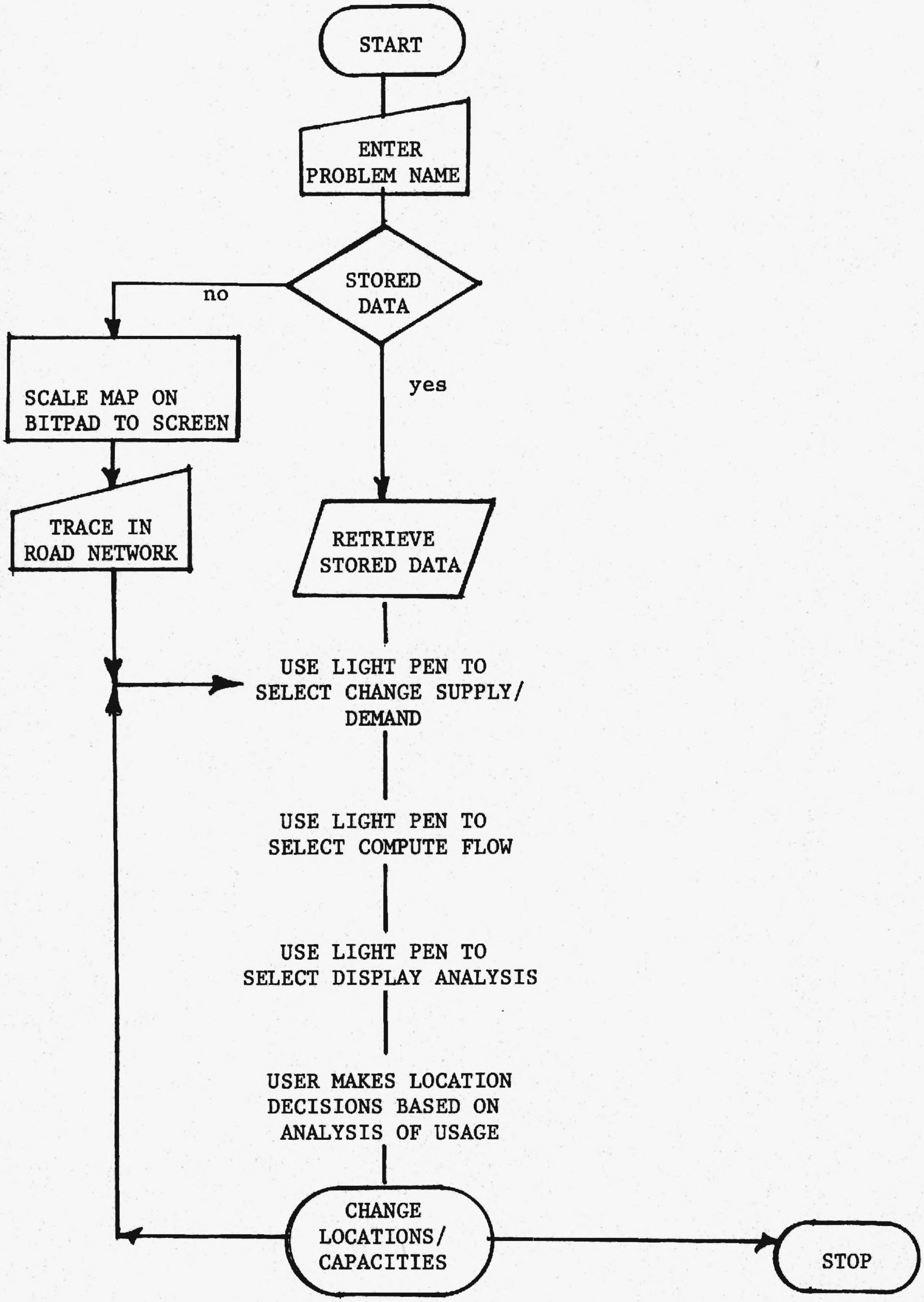


Figure 3. Flowchart of User Actions

unit will have to make in satisfying its demand per day. This integer value is obtained by rounding up.

"The third step is the selection by the user of those water point locations that are to be considered and their respective supply limitations. The minimum of either the amount of water available or capacity of the equipment to purify water is determined and used as that site's supply capacity.

"The fourth step is the computation of all shortest paths from each of the selected water points to all other points in the network.

"The fifth step is the allocation of water supply capacity to units' requirements so that total distance traveled is minimized.

"The sixth step is a sensitivity analysis of the results presented to the user in graphical format. This enables the user to readily identify which of his potential water points are not fully utilized and are therefore, candidates for elimination. Any of the supporting numerical data can be requested and displayed concurrently with the graphs. 'What if' questions may be proposed and analyzed by forcing a particular supported unit to be serviced by a particular water point. This great flexibility for rapid analysis and cross checking allows the user to take into account all of those factors that cannot be accurately or practically modeled, i.e., mission, enemy, terrain and command guidance.

"The seventh step involves the user making a decision as to which sites are to be opened or closed. The user may then return to any of the first three steps and initiate a more thorough analysis. This subsequent analysis can then also be a candidate solution and modified as desired.

Although this procedure is not "optimal" in the classic sense of optimally it does provide the required framework within which the quantitative aspects of the problem can be defined and examined. It also allows the MAF engineer to interact with the problem integrating into the solution process the qualitative factors which only the MAF planner can evaluate.

The code for this interactive program is contained in two sets of code, NTRACE and COMPUTE, which are written in Basic and implemented on a Chromatics CG-1999 color graphics microcomputer with light pen, digitizer (bit pad), 64K bytes memory, and dual 8" floppy disk drives. The Chromatics is also equipped to act as a terminal for larger problems and can ship data sets defining the problem structure to a DEC 11/70 operating as a host computer.

The water point selection program emphasizes the use of a graphic oriented interface between user and machine. Although some of the problem initializing data is keyed into memory (e.g. unit demand and water point capacity) the road net linking units with supply points is generated using a bit pad and a digitizer. Once the problem has been defined, control of the problem and data modification is handled by the use of a light pen by making light pen "hits" menu items or points appearing on the color monitor representing supply points or unit locations. The user's interaction with data set defining the problem is achieved primarily using the light pen and the keying of data is minimized once the problem has been initialized. This is a very attractive feature of this system which would appear to be well adapted to the needs of the MAF engineer and his staff.

The system in its present configuration offers four different graphical reports which can be called up by using a light pen hit on the DISPLAY ANALYSIS menu item. Figure 4 shows the appearance of the monitor screen with the GALLONS SUPPLIED VS SITE # report. The four reports available in this mode are:

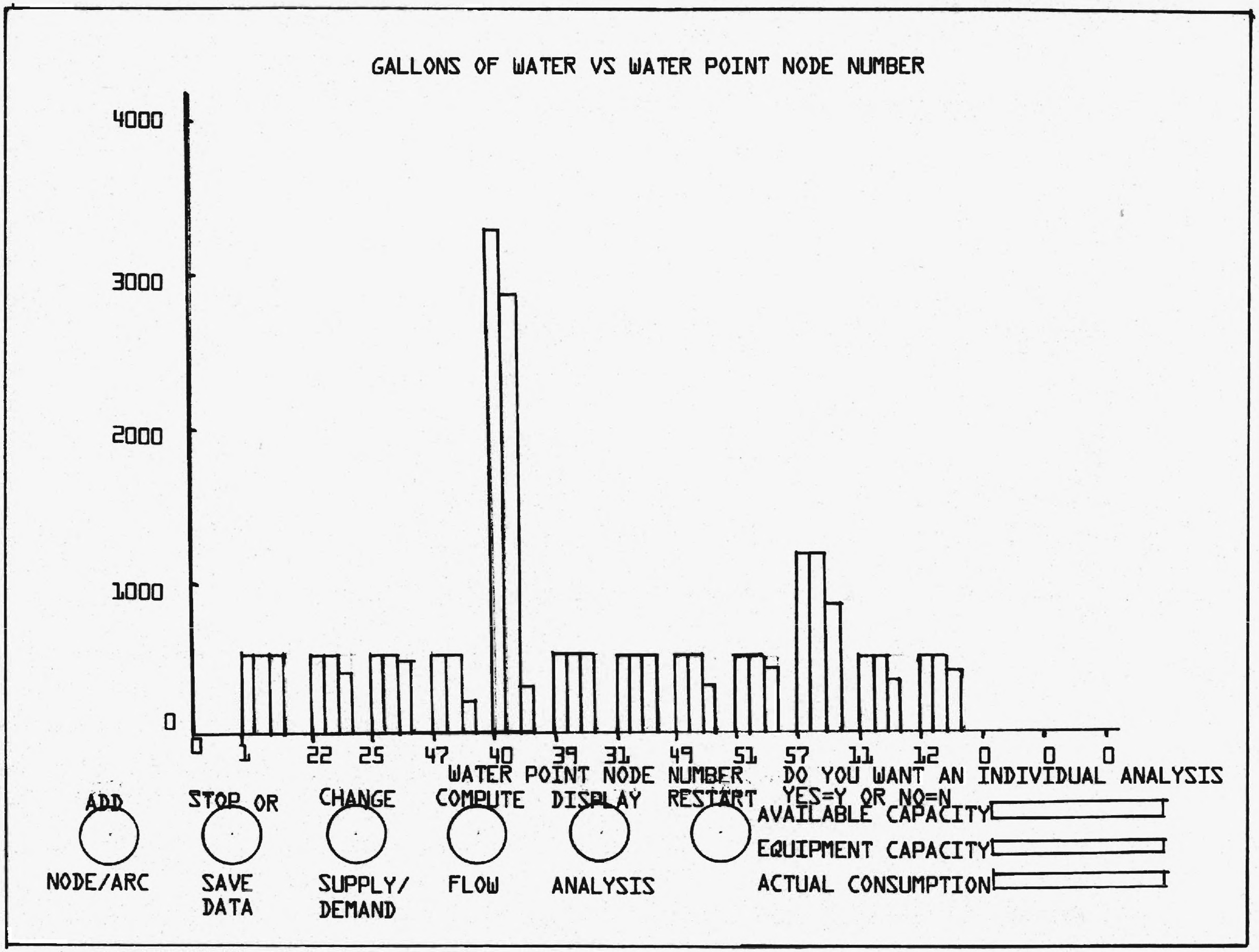


FIGURE 4: Gallons Supplied vs Site #

(1) Gallons supplied vs Site #

(2) Distance travel per gallon vs Site #

(3) Actual Distance traveled vs Unit #

(4) Distance travel vs Alternate Water Point assigned

Additional numerical data is available upon request with each of the report screens noted above by requesting INDIVIDUAL ANALYSIS.

The menu items available with each screen allow the user to move program control into the following modes:

(1) DISPLAY ANALYSIS

(2) RESTART

(3) ADD NODE/ARC

(4) STOP OR SAVE DATA

(5) CHANGE SUPPLY/DEMAND

(6) COMPUTE FLOW

Based on activation of the DISPLAY ANALYSIS menu item the following options are made available at the lower right hand side of the screen:

YOU HAVE A CHOICE OF 4 GRAPHS AND/OR NUMERICAL DATA.

#1 = "GALLONS SUPPLIED VS SITE #"
#2 = "MOST EFFICIENT SUPPLY PT."
#3 = "MOST COSTLY SUPPORTED UNIT"
#4 = "DISTANCE TRAVELED VS SOURCE"
#5 = "INDIVIDUAL ANALYSIS"
#6 = "RESUME LIGHT PEN CONTROL"

Figures 5 and 6 show the flowcharts for program routines NTRACE AND COMPUTE. Routine NTRACE handles the input of data initializing the road network connecting units with supply points. The flowchart for the COMPUTE routine indicates the functions which are activated by "hits" on the menu items.

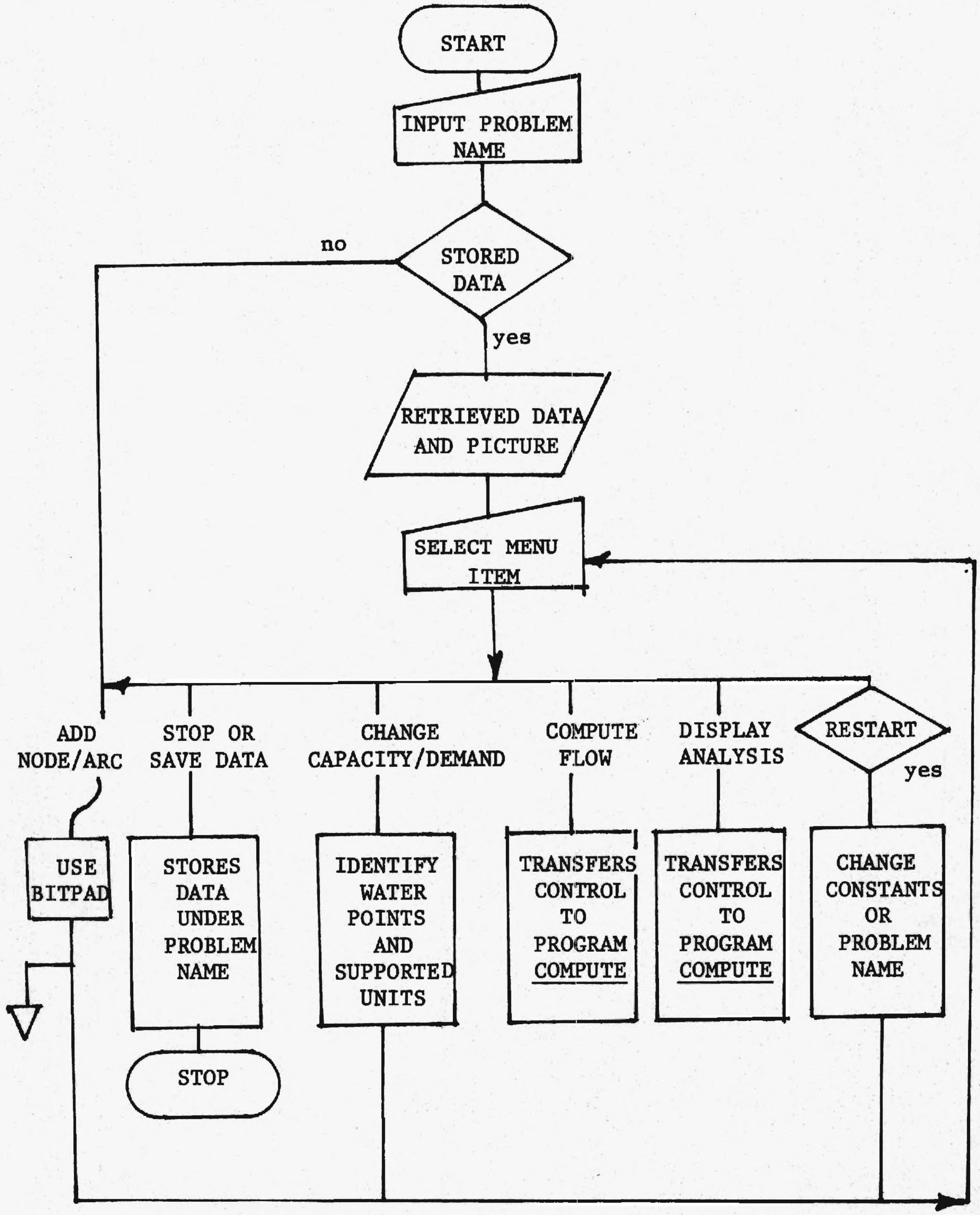


Figure 5. Flowchart of Program NTRACE

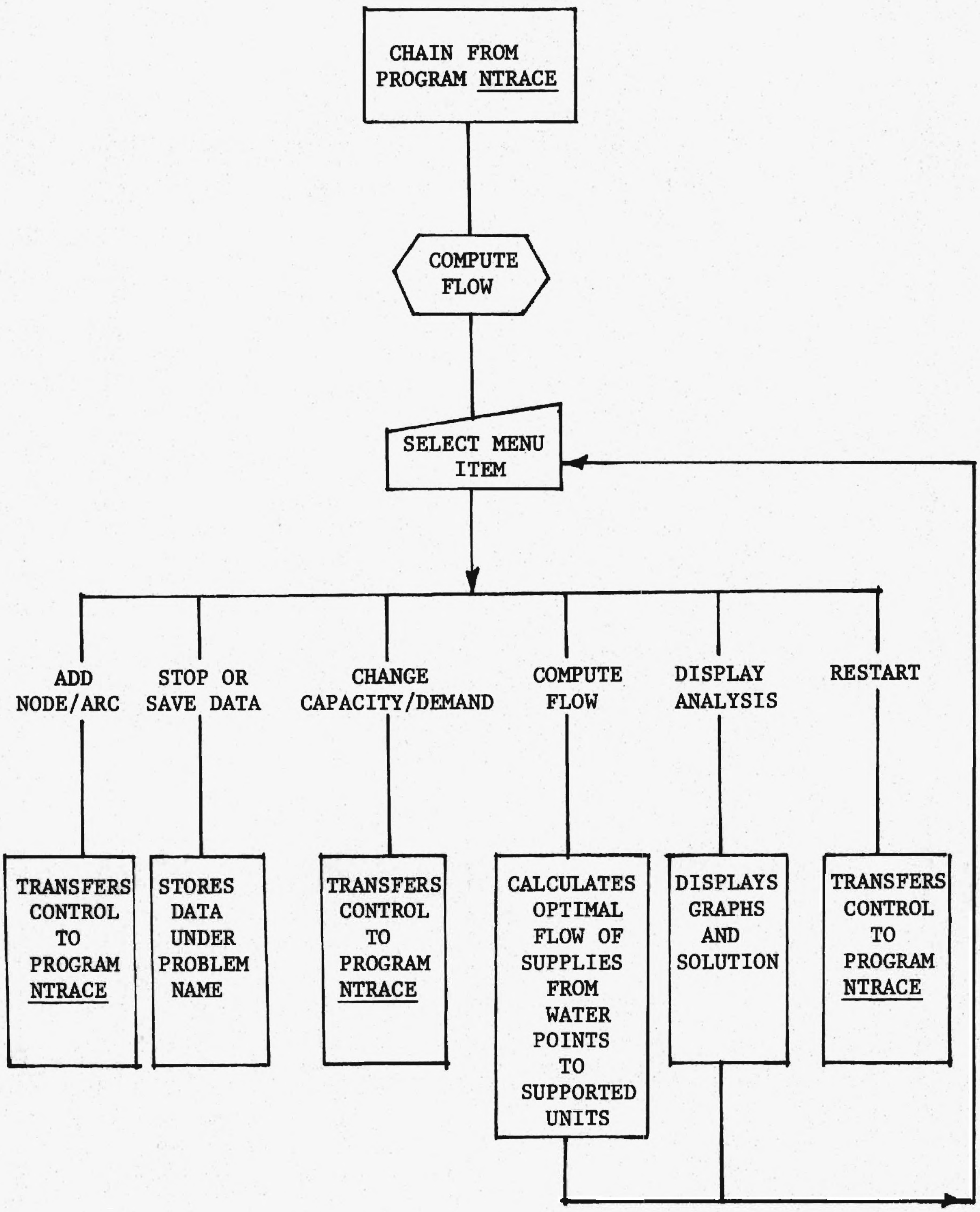


Figure 6. Flowchart of Program COMPUTE

SYSTEM DESIGN PROTOTYPES

PREFABRICATED FLOATING BRIDGING

In an effort to obtain a better understanding of the capabilities of microcomputers for use in addressing the computer aided design needs of the MAF Engineer and the process of system design and software development, prototype programs were developed for two of the MAF engineering tasks listed above. The two systems developed pertain to the prefabricated floating bridge design task and the helicopter landing site and zone preparation design task. The steps used in development of system software are normally defined as follows:

(1) User Request

(2) Feasibility Study

(3) Investigation

(4) Analysis and Design

(5) Programming

(6) Testing

Due to the nature of the objective of the development (i.e. study of methods and problems associated with MAF system design) and the relatively limited amount of time available in this phase of the project, the developmental activity focused on a rather preliminary attempt to perform steps (3), (4), and (5). It was felt that this approach would help in the identification of computer aided design objectives and limitations associated with the use of the microcomputer as well as an opportunity to evaluate the appropriateness of interactive graphics oriented systems versus the parametric structured input-output systems described above. Much of the state of the art material which forms the basis of the investigation step has been discussed in the previous sections.

The prefabricated floating bridge design program is based on the designs found in the Army River Crossing and Bridging Manuals (Field Manual 90-13 and Technical Manual 5-210), for the most common types of float bridging to be found in a river crossing operation (Mobile Assault Bridge, Ribbon Bridge, and M4T6 Bridge). The program uses a simple interactive format with prompting statements to ask for the required input parameters so that any member of the engineer's staff can successfully utilize the program.

The steps used to identify the input parameters and the program format were defined as follows:

(1) Design an idealized output format/model for float bridging to neatly present the information required by the military engineer.

(2) Determine what types of military float bridging are available and applicable to the problem.

(3) Determine what processes and calculations must take place in the design portion of the program.

(4) Determine what storage and file manipulations must occur to give the desired results.

(5) Determine the input variables and procedures for implementation of the design.

In idealizing an output format to neatly present the information provided by the computer aided design, it was determined that the output should be in a neat tabular form and should provide the following information:

(1) River Data

(2) Bridge Classification (Wheeled and Tracked)

(3) Crossing Rate

(4) Construction Time

(5) Number of Required Construction Sites

(6) Bridge Assets Required for Construction

(7) Bridge Assets Remaining after Construction

(8) Special Requirements

(9) Anchorage Requirements

A format for this idealized output information is shown in Figure 7.

In order to determine what types of military tactical float bridging are available for use, and applicable to the Marine Amphibious Force, the Table of Organization and Equipment (TOE) for the MAF and Field Manual 90-13, "River Crossing Operations" were consulted. From these references, the most common types of tactical float bridging used in river crossing operations were found to be the Mobile Assault Bridge (MAB), the Ribbon Bridge, and the M4T6 Bridge.

To determine the processes and calculations that were required in the design portion of the program, the appropriate bridging manuals for each type of available bridging were consulted. During this process, it was decided that the design portion for each type of float bridging should take place in a separate subroutine within the overall program, with other subroutines to be used to receive the data and to route it to the design subroutines, and still other subroutines to route the design information to the output subroutine.

From the information gathered during the implementation of the above steps, a subroutine flow chart (Figure 8) identifying the inter-relationships of the various subroutines found in the program was developed. From the procedures identified for the design process, a detailed flow chart was developed (See Appendix A), which identifies the individual steps required for the overall design. The coded computer program was prepared from the information

MOBILE ASSAULT BRIDGE

RIVER DATA:

WIDTH 99. METERS

VELOCITY 2.8 MPS

DEPTH 1.80 METERS

BRIDGE DATA:

CLASS		RATE	CO	ASS	REQUIRED ASSETS		REMAINING ASSETS	
W	T	VPH	HRS.	SITES	INT	RMP	INT	RMP
55	55	200	.7	1	9	2	6	8

<u>SPECIAL REQUIREMENTS</u>

NONE

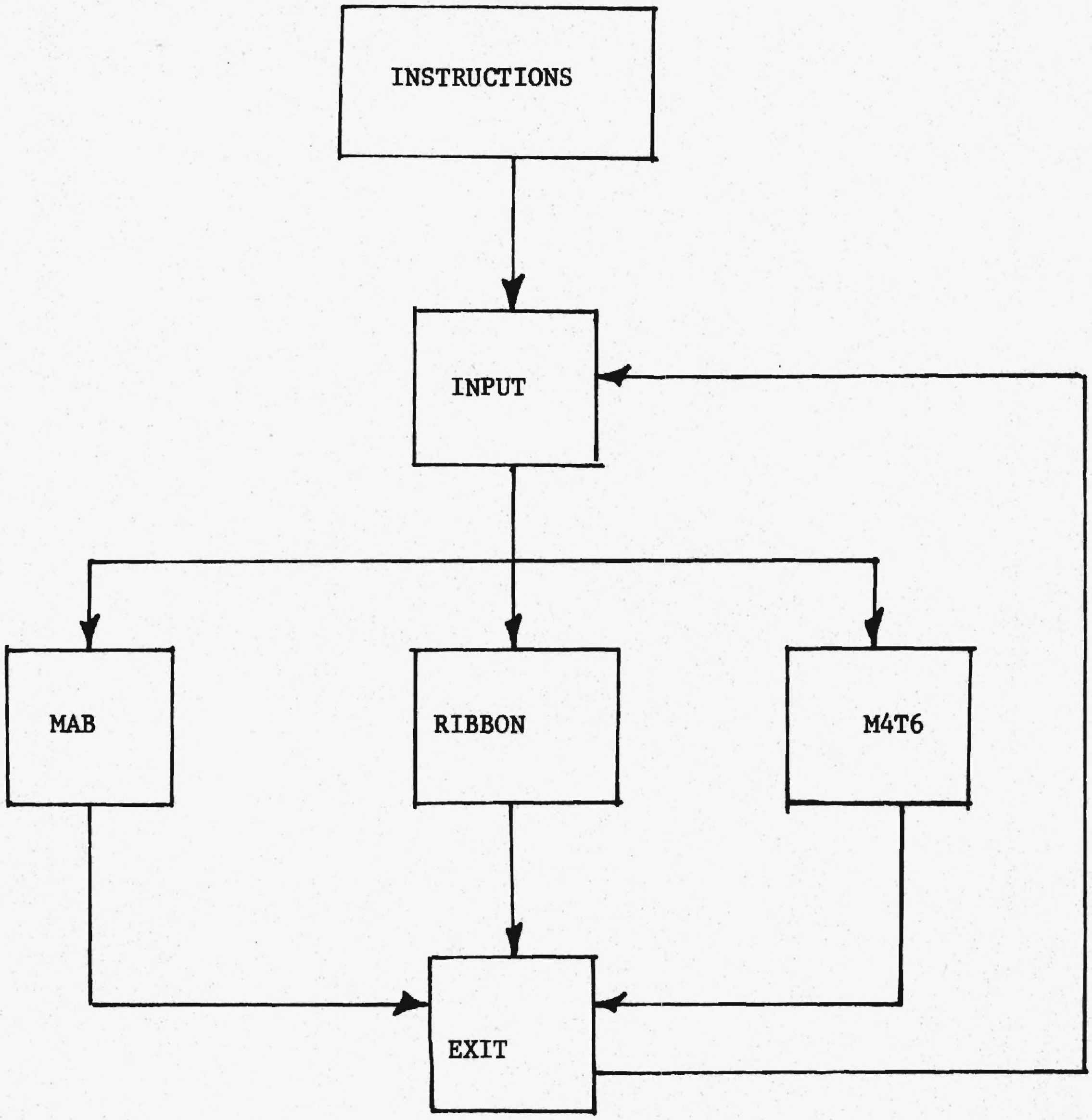
<u>ANCHORAGE REQUIREMENTS</u>

THIS BRIDGE REQUIRES NO ADDITIONAL ANCHORAGE

Figure 7: Idealized Prefabricated Floating Bridge Program Output.

FIGURE 8

SUBROUTINE FLOW CHART



provided in the detailed flow chart. A listing of the coded program is found in Appendix B.

The capabilities of this computer aided design include routines that analyze the input data for the feasibility of using float bridging for the conditions given. If the input variables indicate that float bridging is not feasible, alternative methods of river crossing are offered. With valid input, this program will provide the following information to the military engineer:

(1) River Data (Width, Depth, and Velocity)

(2) Bridge Classification (Wheeled and Tracked)

(3) Crossing Rate (Vehicles per Hour)

(4) Bridge Construction Time (Platoon and/or Company Hrs.)

(5) Required Number of Assembly Sites

(6) Required Bridge Assets

(7) Remaining Bridge Assets

(8) Any Special Requirements

(9) Anchorage Requirements

The design includes the capability to use standard resource packages (Corps or Division Engineer Bridge Assets), or to have the available bridge assets input into the program. It also offers the capability to use the remaining assets (if desired) in the design of any subsequent bridges.

The program was designed to be flexible enough to be adapted to the fluid battlefield situation without deviating from any of the standard military practices or doctrines.

In the input phase of the program, the user follows the following steps to provide the required information:

(1) The computer asks the user if it has a full complement of TOE bridging assets as defined in the MAF. If not, the computer will ask that the available bridging assets be input in the program. (Bridge Type i.e. # sets/bays)

(2) The computer then asks for the river variables:

(a) River width in meters

(b) River depth in meters

(c) River velocity in meters/sec

These variables will have limitations placed on them to prevent the program from having an infeasible solution. The program will tell the user to use fixed bridging, obtain additional bridge assets, or to ford the river depending on the input supplied.

(3) The computer then asks the following questions about the bridging operation:

(a) What type of bridge is to be built?

(Enter one or any combination of bridge types)

(b) Will the bridge be placed during day, night, or under adverse conditions?

All information is input in response to computer questions and is provided to the computer by typing the information on the CRT or the tele-type printer.

The processing portion of the program consists of a subroutine for each of the four types of bridging assets. Within each of the subroutines, the following functions are calculated or retrieved from existing files:

(1) Read in data

(2) Calculate # of bays/sets/pontons of bridge type are required

(3) Calculate remaining bridge assets

(4) Determine class of bridge under Normal, Caution, and Risk crossings

(5) Determine the total construction time, man-hours, and platoon-hours

(6) Determine the number of required assembly sites

(7) Determine the bridge crossing rate

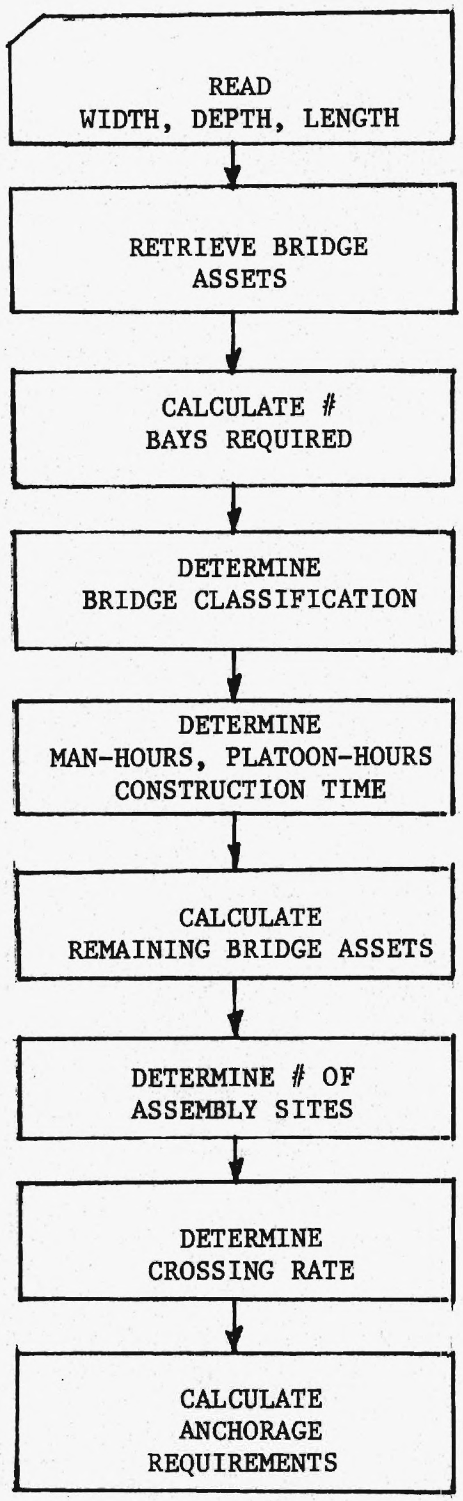
(8) Calculate anchorage requirements

In non-computer aided design, the majority of this information is determined from charts found in the appropriate bridge manuals. In this program these tables/charts will be stored such that they can be recalled and sorted to find the required information given the various input parameters. A macro-flowchart for the processing stage of the program is provided in Figure 9.

This program can be easily modified to include other standard floating bridge assets such as the light tactical raft (LTR), the aluminum foot bridge, or any other newly developed form of bridging assets. The program can also be modified to include sub-routines that would develop rafting capabilities of the bridge assets. By combining the capabilities of both the raft and bridging capabilities with the vehicle crossing requirements of a Hasty or Deliberate River Crossing, a vehicle crossing chart can be developed that would provide the tactical commander with a crossing schedule that would tell him how long it would take to cross his force, the bridging and rafting requirements, and an aid for the crossing traffic flow.

In setting up the input data and the calculation of the various bridge assets, the following steps were employed:

Figure 9 Macro Flow Chart



(1) Collection of information

(2) Design process needed

(3) Calculations required

(4) Output and final design

(5) Decision as to whether the output is adequate

(6) Feedback if more processing is needed

In this system of processing the desired information, prompting statements were employed. This lets the operator obtain the desired information quickly and efficiently without the problem of possibly missing required input data and delaying the program.

This program is simple to use, and the output is simple to read. It would be difficult to enhance the program with graphical or other printed output because of its simplicity. Additionally, this program, along with other programs, can be employed as a feeder or a subroutine in a larger reporting system which incorporates graphical methods for representing the interaction of activities. This program was kept as simple and as straight forward as possible so that it would not use large quantities of computer time and core memory.

SYSTEM DESIGN PROTOTYPES

HELICOPTER LANDING SITES AND

ZONE PREPARATION

Development of a system which provides computer assistance to the MAF engineer designing helicopter landing sites and zone preparation in the amphibious operations area of a Marine Amphibious Force must address the concerns of utility, ease in understanding input requirements and output data, speed of data provision, and accuracy. The problem area essentially deals with compilation of data from various technical manuals and publications (see references) and formulation of a logical, sequential progression through the heliport design process.

As the Department of the Navy does not have any standard design publications concerned with the problem area, use of Army and Air Force technical manuals was employed for solution development. The proposed solution should provide a sound basis for design criteria employed by the Navy as there is a certain uniformity of helicopter type and function throughout the combat services. The flexibility of the prototype program developed in this study is achieved through its consideration of the various helicopter types; however, a computer program cannot apply certain "common sense" logic which must be applied when field situations warrant such. Additionally, program development revolved around provision of a multisite analysis capability in order to select the "best" overall alternative. This is in contrast to site selection based on limited considerations of construction desirability as determined by the designer/engineer.

The Navy and Marine Corps helicopters which were used as a design basis for the development of a prototype program are the AH-1, UH-1, CH-46, and the CH-53.

Research indicated that there is no comprehensive design program available for application to helicopter landing sites, but that various programs have been developed to address a specific facet of the design process (e.g., cut and fill program which allows establishment of design elevations through balancing the cut and fill). The current design process involves extracting dimensions, grades, specifications, etc., from various technical manuals to establish the proper landing site layout and configuration.

There are a variety of site selection techniques which may be employed, including manual operation of the constructive effort comparisons incorporated in the proposed solution. An optimization technique is proposed by Ford, Bacon and Davis - in Report No. CR 79.001, CEL, October 1928. The proposed approach utilizes the same basic factors which the technical manual equations use, but the optimization over an entire area is the noteworthy difference. The optimization proposed by the technical manuals is left up to the manipulation of the site by the evaluator.

In an actual amphibious operation, site planning for establishment of helicopter landing sites is in all likelihood limited to designation of open, easily accessible areas as the candidate zones. These areas may or may not prove useful for forward or support area development. Therefore, it is highly probably that little or no design occurs prior to the actual amphibious assault (what does occur is probably disregarded as invalid once actual occupation of the area is established). This then would tend to indicate that considerable field oriented decision-making is undertaken without a design basis, and in turn valuable time and engineering effort is consumed.

DESCRIPTION OF THE
HELICOPTER LANDING SITE SYSTEM

The proposed system was designed to accomplish the objectives of:

(1) Provide design criteria for the heliport/landing site based upon the type of helicopters to be served by the site.

(2) Provide pavement design criteria for landing surfaces to be employed.

(3) Provide guidelines as to the soil stabilization requirements for the landing zone.

(4) Calculate the construction effort for the heliport/landing zone based on a particular site.

(5) Provide gross material and manpower estimates for construction based on the proposed design.

(6) Provide template dimensions for the various landing site configurations.

The steps employed in the program design process were as follows:

(1) Establish the process functions which could provide the desired results.

(2) Develop the required input for the functional process.

(3) Formulate the anticipated output and its format.

(4) Establish subroutine segregation of the various processes.

(5) Identify those interactive variables.

(6) Evaluate input/output methods.

(7) Address computer storage minimization

Actual development of the code was based on the use of a terminal interface with a CYBER 74 computer support and FORTRAN language. The intent of the developers was to simplify the input requirements to the extent that user knowledge of design techniques and computer technology can be quite limited. Use of the program itself is not limited to any particular entity. The field engineer can apply the output to verify specifications or answer a particular question concerning an existing design. The designer can apply the procedure to initiate the design of a landing site which has not been developed. An estimator may utilize portions of the output to develop material and manpower requirements for construction of the landing site. The planner can use the program to evaluate various proposed sites on the basis of construction effort.

The program is interactive through the use of prompting questions and directions as to how the response is to be provided. (It is possible to use some secondary file input, but the main concern was for interaction.) When a multiplicity of landing sites are to be compared, the file input can afford greater time savings.

Requirements for the input data are such that some preliminary work must be done prior to use of the program. Data such as the site's soil condition, soil thickness, vegetation, terrain slope characteristics, airfield index of subgrade, plastic index of subgrade, helicopter types to be using the landing site, desired configuration and construction force to be employed must be established prior to any computer work. The data is obtainable from a variety of sources, and much of it may be projected from aerial photographs or surveillance reports. There are more items of information which will be extracted from tables and charts incorporated into the user's manual.

Processing of the input data addresses the constructive effort calculations, design specification compilation, and gross material and manpower calculations (note: cut and fill computations are not accomplished by this program). The detailed flow chart in Appendix C reveals the process sequence and subroutine organization.

The program output is formatted such that the minimum amount of information is presented to clearly convey the results of the processing functions. Since specifications as well as computed results are output, the output may be quite extensive. The specifications are written in sentence form for clarity, and all figures are defined and presented in sentence or tabular form. The output obtained depends upon the desires of the user. Prompting questions will establish what outputs are to be printed, and this process is sequential (i.e., one subroutine will be accomplished before the computer asks if the successor routine(s) is/are desired). Again, the intent was to maintain simplicity, but also to maintain accuracy and effectiveness.

HELICOPTER LANDING SITE

PROGRAM OVERVIEW

This computer aided design is an effort to accelerate the evaluation and design of heliports through use construction techniques. The program combines the construction effort evaluation methodology provided by the Ford, Bacon, and Davis study the information and specifications provided by the various military publications (reference TM5-330 is the primary resource) and assorted manipulating functions within the program to provide appropriate design specifications.

In order to accomplish this end, the user is required to input various pieces of information to the computer. The necessary input is prompted by questions from the computer followed by the answering keys. The input consists of the following data:

(1) terrain coding (TM5-330);

(2) vegetation coding (TM5-330)

(3) soil type and condition TM5-330);

(4) CBR of subgrade, subbase, and base materials;

(5) types of helicopters to use area;

(6) number of helicopters to use area;

(7) type of heliport desired (forward or support);

(8) type of construction force;

(9) airfield configuration desired;

(10) airfield surface desired;

(11) stabilization information (membrane, matting, asphaltic concrete);

(12) plastic index of subgrade;

(13) airfield index of subgrade;

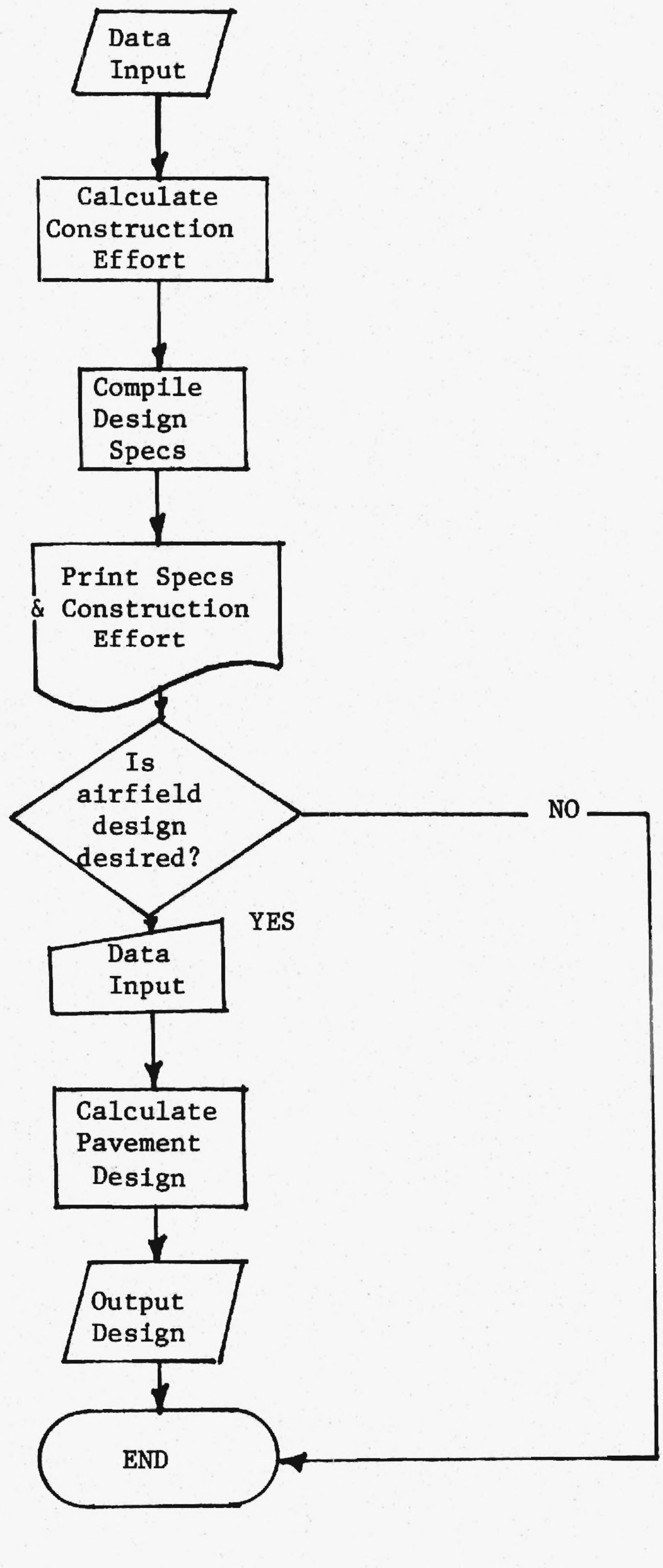
(14) selected input from graphs and charts accompaning the user's manual.

This input is obtained through maps, information about the AOA and the requirements of the MAF. The program is configured to input the data by keying the response in on a terminal or monitor.

Processing within the program consists of construction effort calculations, surfacing design specifications and compilation of the appropriate field design data. Figure 10 depicts the macro flow chart for this program.

To be most easily understood, the specifications regarding the airfield (landing pads, etc.) are printed out in simple verbage. Modifications of the program will allow print out of various other design information to include the strip/pad layout, clear zones, safety zones and fuel areas. (See user's manual - Appendix D) The construction effort is printed out in tabular form. The remainder of the output is presented in simple sentences.

FIGURE 10: HELIPORT PROGRAM MACRO-FLOW CHART



LIMITATIONS AND ENHANCEMENTS

The prototype program was developed as a working version to test some of the concepts of the research team regarding computer aided design. It is only a starting point in solving the helicopter landing site problem. Since there are several variables, tables and graphs from which input values must be user generated, and a variety of data arrays which must be stored, a central file with the appropriate data would enhance the program's operational time and reduce local file storage. The basic process was developed to provide the desired output with as much internal "housecleaning" as was possible. Modification to implement the program in a microcomputer environment is required.

As was stated earlier, no system could be located which provides the same data as the proposed program. Other routines dealing with various specific aspects of the design procedure could easily be added to the program to develop a more complete package of design effort. There are a variety of such routines available for evaluation and/or inclusion.

The principal effect of the program is intended to be a reduction in the resource library requirement of the engineering force and the research time required for the detailed planning/design of this type construction. Additionally, this program provides for the detailed planning and design information base down to battalion level. The program will also provide inputs to the other engineering management systems that control manpower, material and equipment resource allocation.

In addition to the benefits of time and workload reduction in the design process, the program allows "on-site" developments, which in turn allow more accuracy in the design phase. The computer aided design program allows rapid analysis of alternative heliport/landing sites and permits the selection of the best site/construction method combination to satisfy the objective of the Marine Amphibious Force.

Limitations to use and application of this program correspond directly to several of the foreseen enhancements. A list of the limitations includes:

(1) The AV-8 "Harrier" is not considered in the program. Inclusion of the specifications for the "Harrier" (VTOL) would require program modifications.

(2) The program does not make allowance for any larger helicopters than those already programmed. Development of larger helicopters would necessitate modification of the program.

(3) Weather (climate) extremes are not reflected in the design and construction methods, and only conventional techniques are considered for both processes (e.g., perma-frost and ice construction would not be appropriate applications of the program).

(4) Equipment requirements are not addressed as output.

(5) Pavement selection is limited to a small variety.

(6) Pavement design employs a simplified technique.

Enhancements beyond overcoming the limitations are varied as well. These might include:

(1) Inclusion of a routine to plot the field layout and depict the various dimensions and specifications that are printed.

(2) A routine which would plot cross sections of the subgrades, bases, pavement, etc.

(3) Inclusion of a routine which would detail the procedures necessary to accomplish construction of the specified landing site (CPM, resource requirements, etc....).

(4) Application of color graphics to a plotted field layout would enhance the readability of the output by color coding runways, taxiways, hoverlanes, clear zones, approach-departure zones, etc.

(5) Graphics to show cross sections which could be light pen modified.

(6) Use of light pen/menu selection for data input and output selection.

(7) Design graphs/charts displayed on CRT with the value selection by light pen.

(8) Inclusion of cut/fill programs, or other programs which would further detail the design process.

(9) The pavement portion of the program can be modified to accomodate a hand held programmable calculator for use at the company level.

(10) The program could be modified to include design for such areas as services roads, drainage and cargo staging areas.

COMPATIBILITY OF COMPUTER AIDED DESIGN SYSTEMS WITH TEKTRONIX 4052

The prototype programs developed are compatible with the Tektronix 4052. There are, however, in the preceding sections limitations that must be overcome. Additional memory storage is required to accommodate these programs. The 4052 has 32K bytes of memory. However, it is felt that 64K bytes is the minimum memory required to facilitate the running of these programs. The second limitation is one of language. The program prototypes have been written in FORTRAN; the Tektronix unit operates with BASIC language.

Both of these limitations can be easily overcome. The memory storage can be increased to 64K bytes by the purchase of a Tektronix optional central processing unit or the use of the 4052 to interface with a backup machine such as a DEC 11/32. The language problem can be rectified by translation of the program into BASIC.

Of major concern is limitations on future improvements to the programs for the Tektronix 4052. The programs as developed envision the use of a light pen for selection of options by the user. However, Tektronix does not provide this option. Light pen usage is ideal since it creates a viable option to typing in a response. The mere fact that one has to type can form a negative attitude in some users. Another concern is the total lack of color in the CRT display. Color graphics can dramatically enhance a display of data.

On the other hand, the Tektronix bit pad and plotter can enhance the helo design program dramatically. By entering topographic data on the bit pad, construction type plot plans can be expertly drafted by this computer. These plots can be placed on drafting paper or transparencies for use in briefings or as overlays.

CONCLUSIONS

Based on the existing programs studied and the prototype program developed the following conclusions can be made:

(1) In military engineering associated with the development of the MAF mission in the AOA the design tasks are modular and related to the item being designed. Therefore, the design procedures for laying out the obstacle plan are based on references and criteria which differ from those used for designing the Expeditionary Air Field. Although all design tasks are clearly related in that a common area and common organization are involved, the nature of design development for the major elements of the AOA requires retreival of information and design criteria for separate procedural and technical manuals.

(2) The design function in combat military engineering differs from engineering in the peace time situation, in that, the facilities being designed are expedient in nature and well documented procedures (coordinated with military doctrine) exist for the design of these facilities. The military engineer's problem, then,is one of site adapting existing "optimal" procedures to the mission area designated.

It is in this area of "processing" site (i.e. operational area) related information that the computer can be of assistance. The retrieval and application of the proper design procedures can be accomplished with great efficiency provided the procedures have been arranged in program format in the computer in such a way that the planner/designer can readily access them using program parameters. Small computers (in some cases hand held) are well adapted to the function of accessing the appropriate procedures in the form of structured data bases and program segments, retrieving them, passing the input information regarding the site to these routines, and outputing the engineer decision information in a compact and, in some instances, graphical format. The input required of the user is parametic and the user must make certain structured input to the procedure. That is, the information regarding the site or operational area must be related to the input variables or parameters required by the procedure. For this reason, one set of computer aided design problems can be considered to be "parametric" in nature.

(3) Another set of problems relates to the selection of alternatives once a design criteria has been applied. This type of problem can be solved to achieve a theoretically optimal solution. The water point location-allocation problem described in the Section on interactive graphics is typical of this type of problem. This location allocation type problem structure can also be applied to the Fuel Storage Distribution and Electrical Service Installation type engineering tasks. This category of design task might be considered to be an "interactive" type of activity as opposed to the "parametric" data retrieval type activity described above. Interactive systems are enhanced by the use of graphical displays and, instances such as the water point problem, input using bit-pads and digitizing devices. The use of sophiscated graphics does carry with it an overhead in additional code and may lead to a certain amount of machine dependence. The question arises as to how

transportable a given design system must be in terms of moving it from one machine to another.

(4) Clearly, implementation of computer aided design procedures on small transportable computers (microcomputers or hand held) can accelerate the application of present MAF design procedures which require time consuming searches of the technical and field manuals. As once a problem is specified to the computer, the manipulation of data and the checking of a variety of solutions to find the best fit (i.e. sensitivity analysis using a range of input parameters) is enhanced. The computer approach brings the additional advantage of providing a structured format in which the MAF engineer must interface with the design procedure. The data requirements are specified by the program. As implemented in the prototype programs prompting messages operate to lead the designer/planner through the design sequence in a step by step manner. There is no question of "what do I do now." The matter of interacting with the program leads to a session format which all Marine Engineer Officers can be introduced to in the Basic Officer's course. This formating aspect of the computer implementation leads to a standardization of planning and preparation which is desirable in the time constrained situation of mobilizing the MAF in combat. The computer also leads to the accumulation of information (data files) as various programs are activated which provides the basis for an operational data base as the operation proceeds. Once basic programs have been implemented in the microcomputer environment, further research should focus on the development and structure of a number of application oriented

programs. Since data is generated and retained by the design support programs, the computer not only supports the operation in the planning stage, but provides ongoing support as the operation develops.

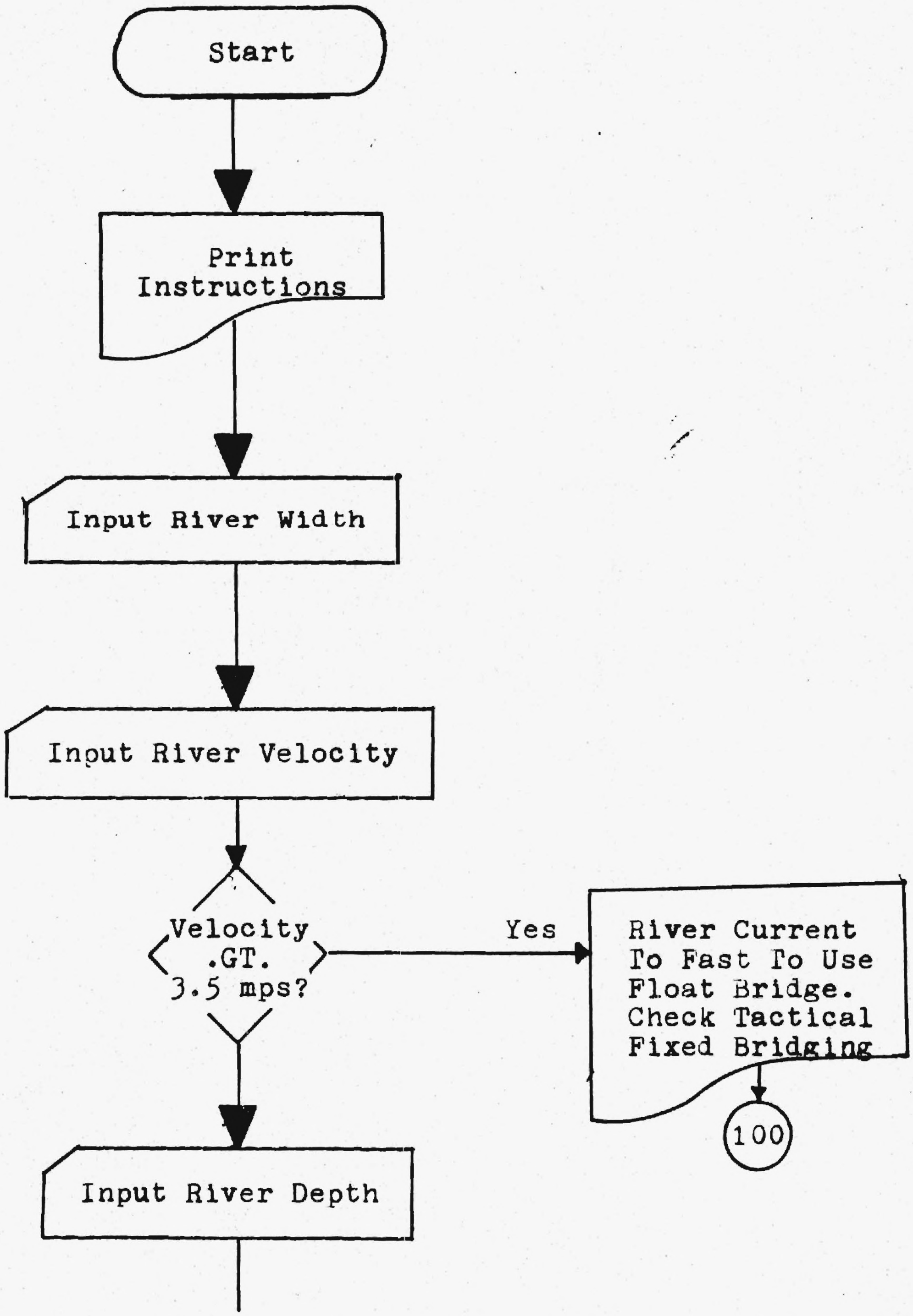
(5) The generation of charts, specifications, tables, effort estimates and a host of other documents in "hard copy" form leads to a level of operational documentation which has been minimal in combat operations.

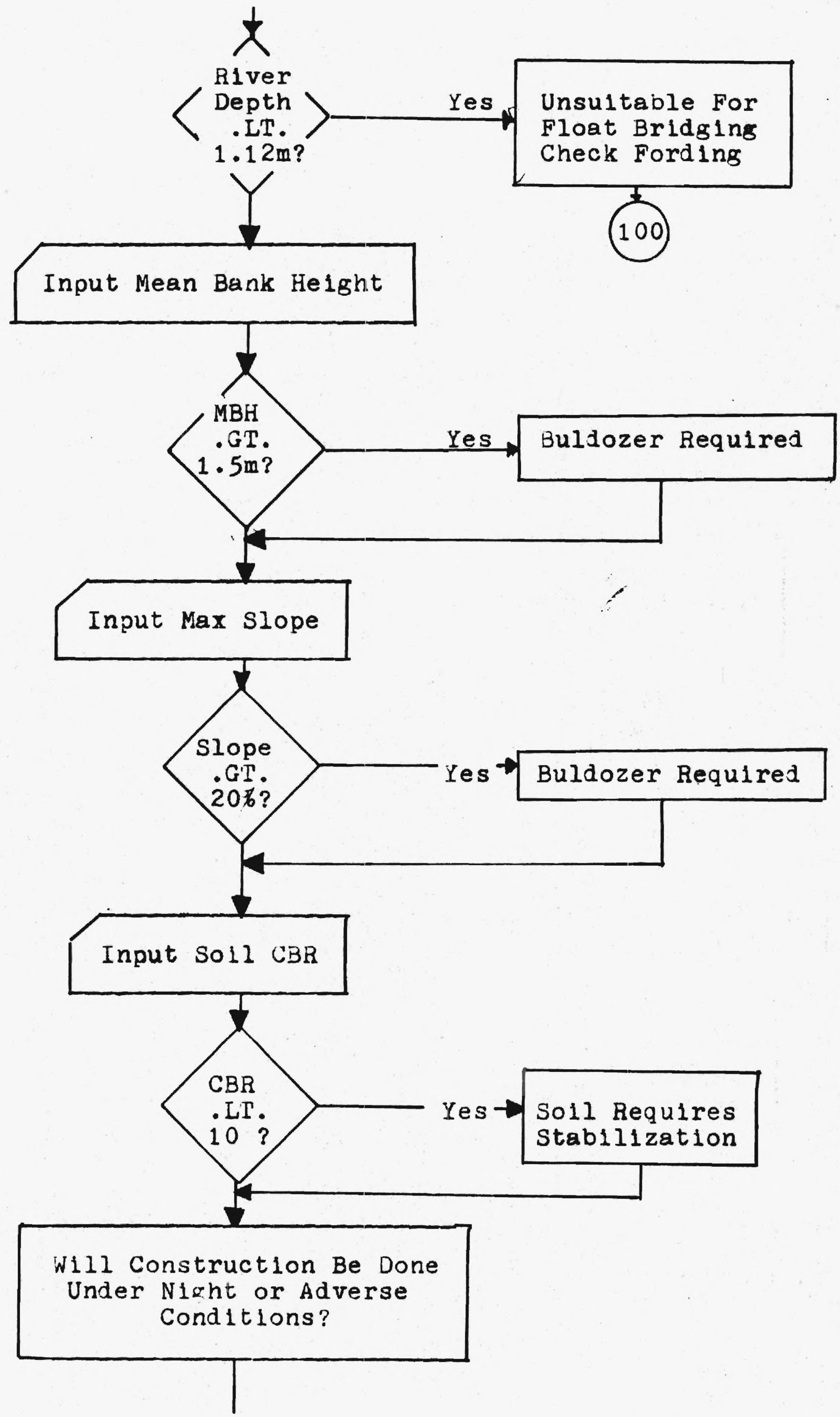
(6) Due to the environmental complexity of a combat situation, the programs themselves have to be as straight forward and simple to use as possible. There is little time in combat to develop proficiency with a complex program. For this reason, simplicity of input and readability of output is a must.

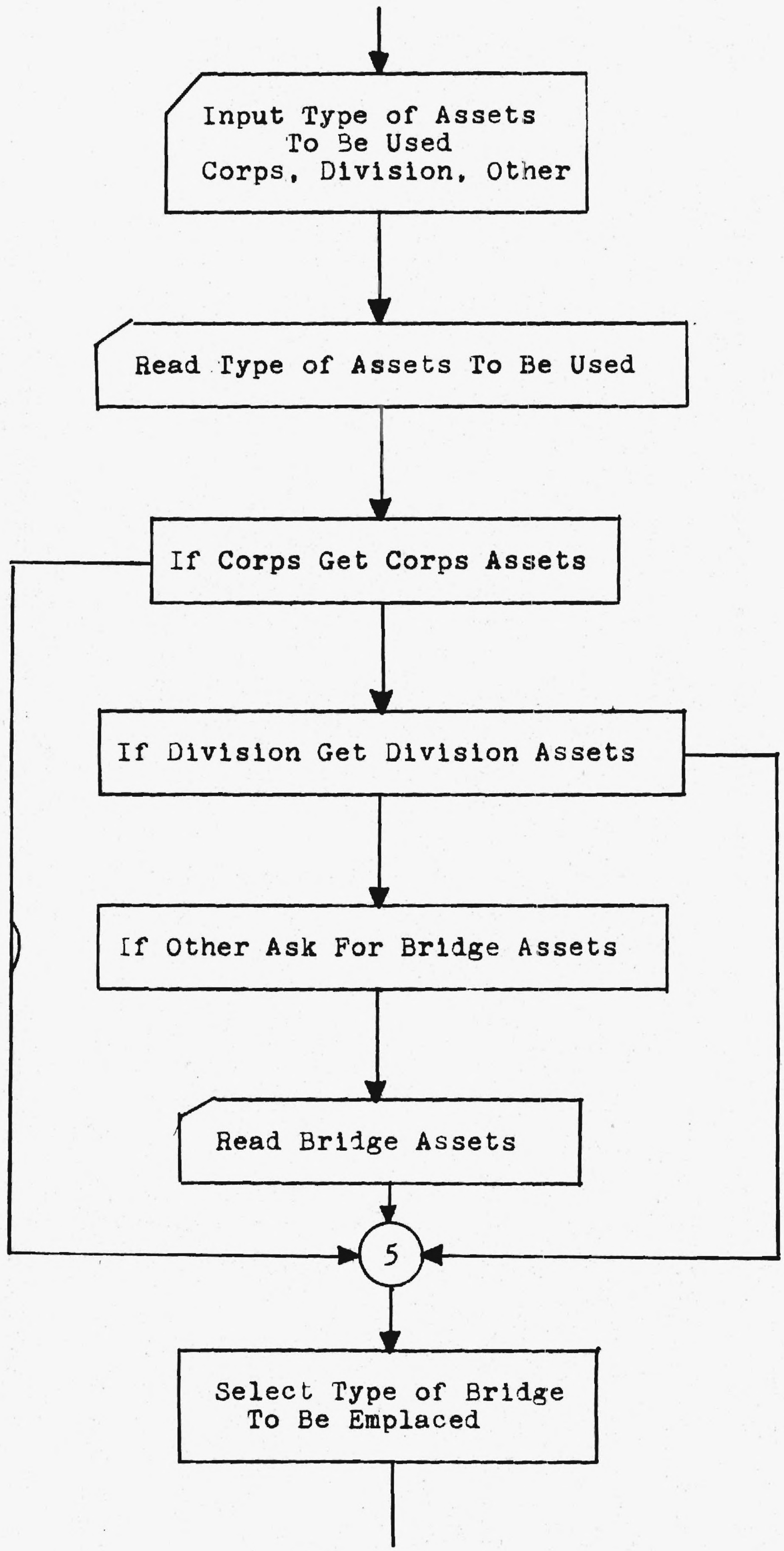
APPENDIX A

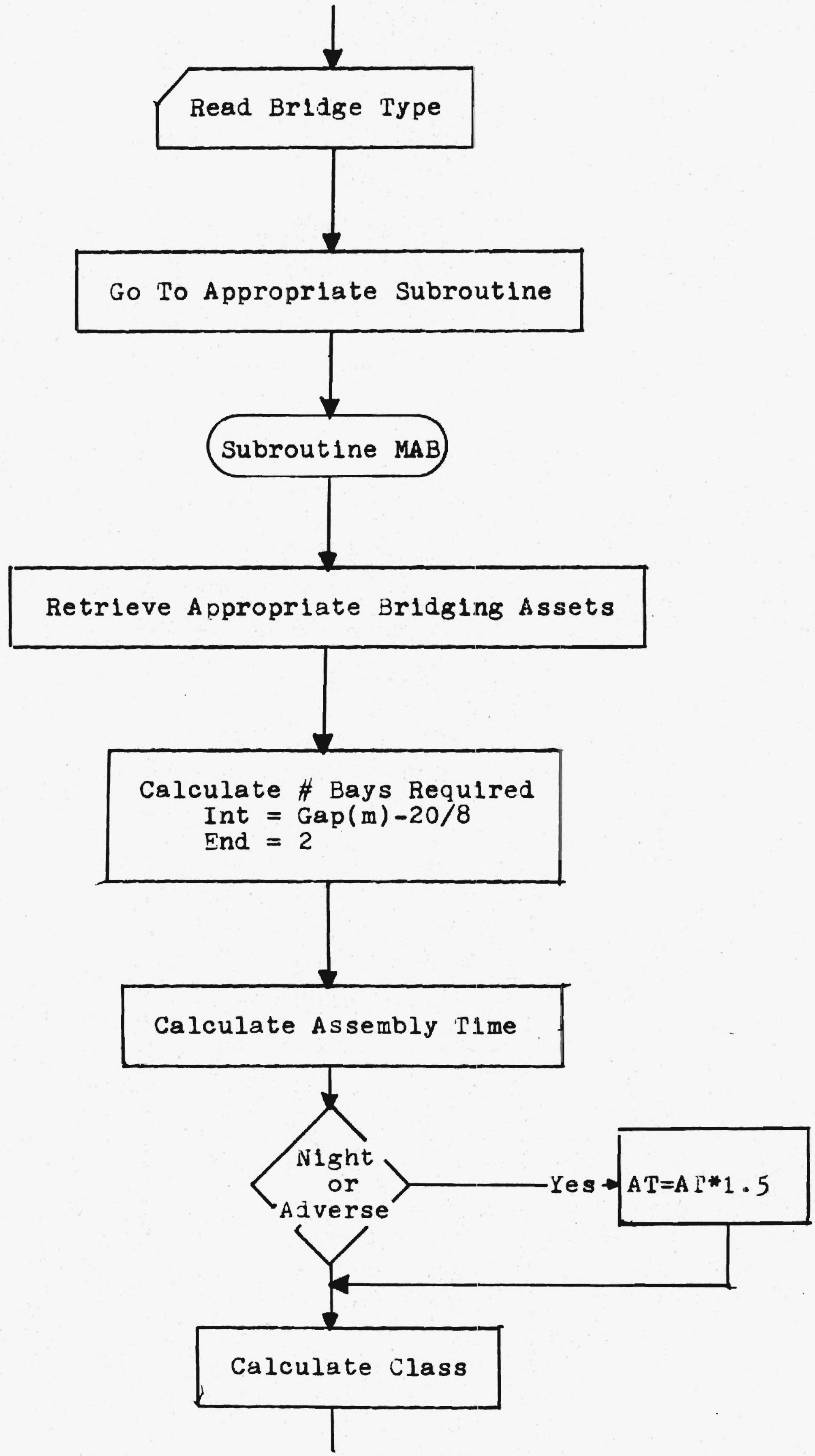
DETAILED FLOW CHART FOR THE PREFABRICATED FLOATING BRIDGE PROGRAM

FLOW CHART

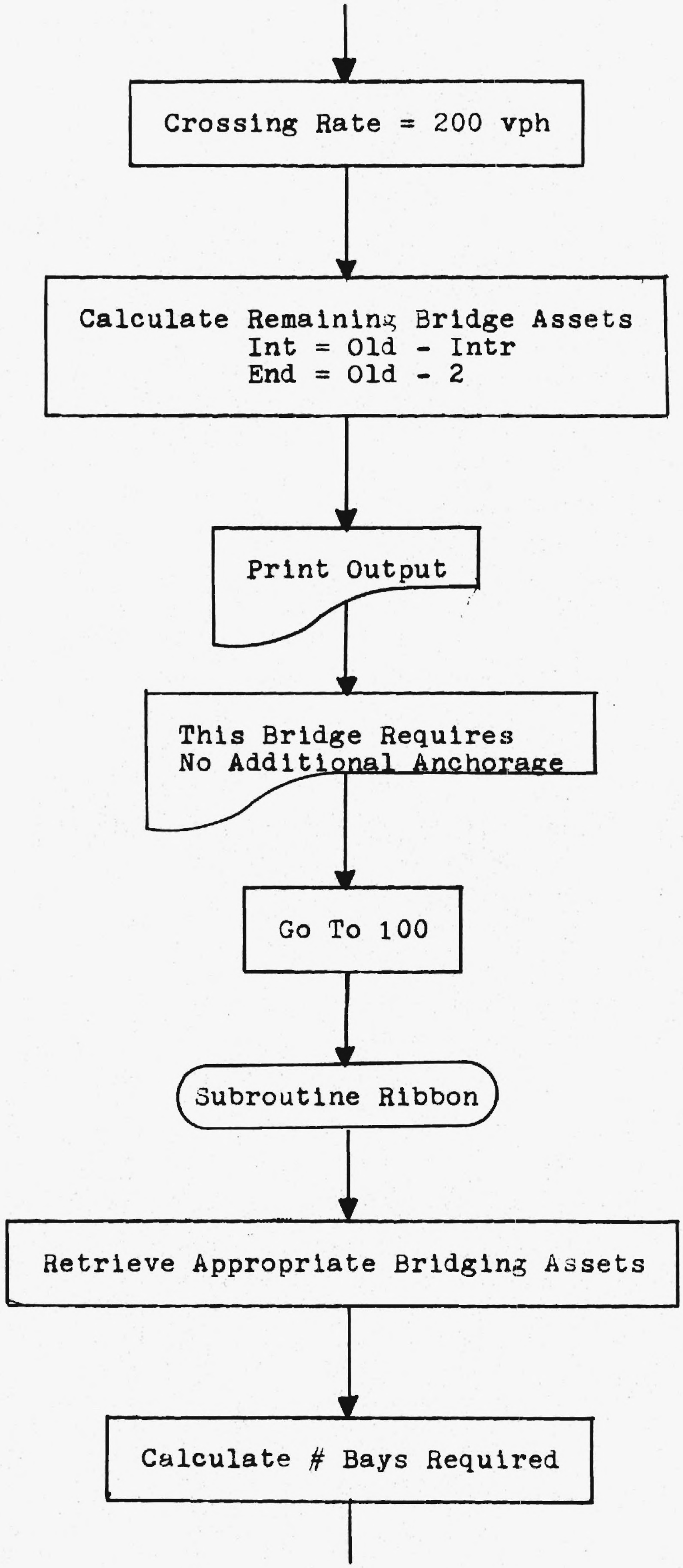

Start
Print Instructions
Input River Width
Input River Velocity
Velocity .GT. 3.5 mps?
Yes
River Current To Fast To Use Float Bridge. Check Tactical Fixed Bridging
100
Input River Depth

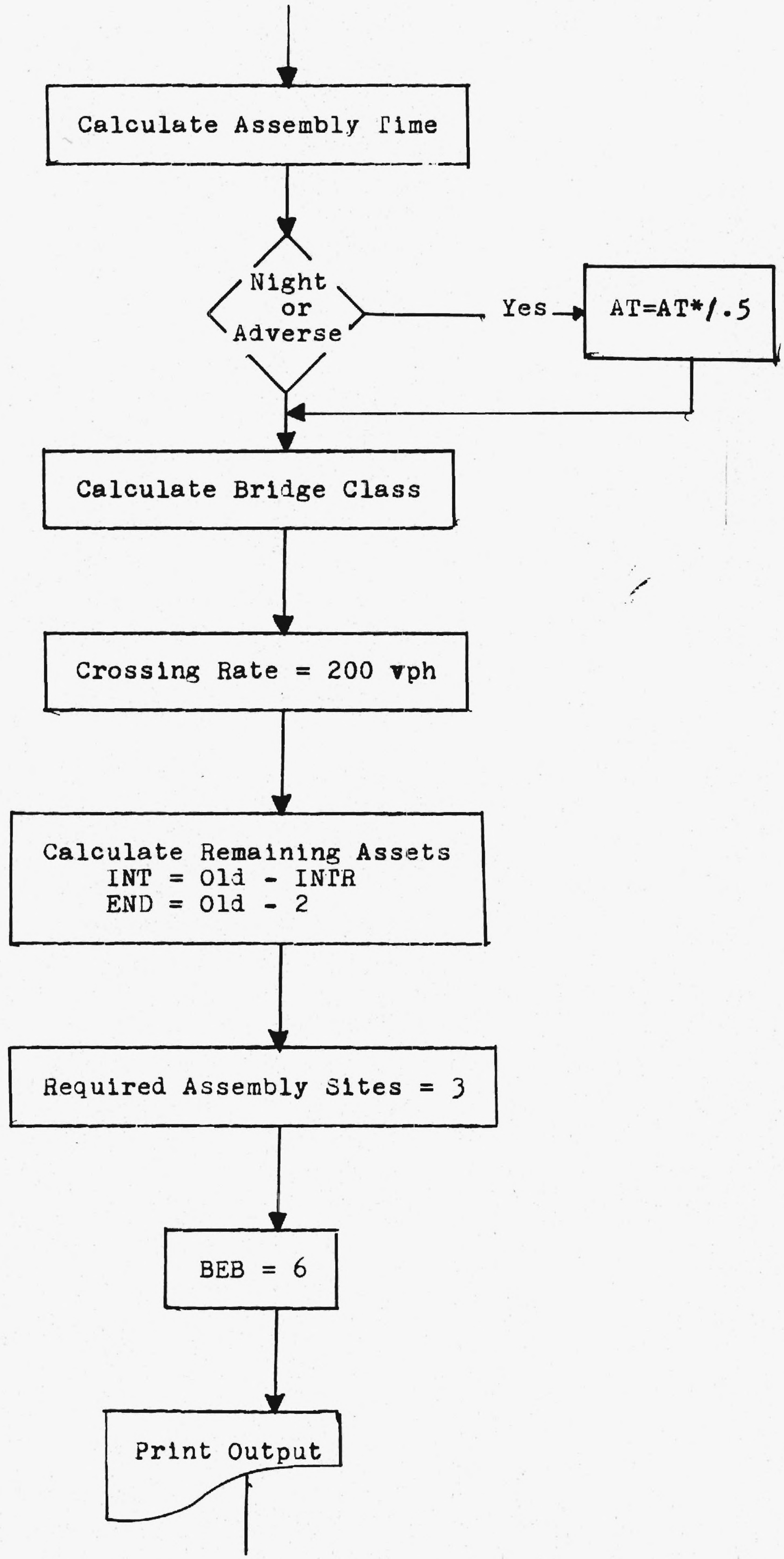

River Depth .LT. 1.12m?
Yes
Unsuitable For Float Bridging Check Fording
100
Input Mean Bank Height
MBH .GT. 1.5m?
Yes
Buldozer Required
Input Max Slope
Slope .GT. 20%?
Yes
Buldozer Required
Input Soil CBR
CBR .LT. 10 ?
Yes
Soil Requires Stabilization
Will Construction Be Done Under Night or Adverse Conditions?

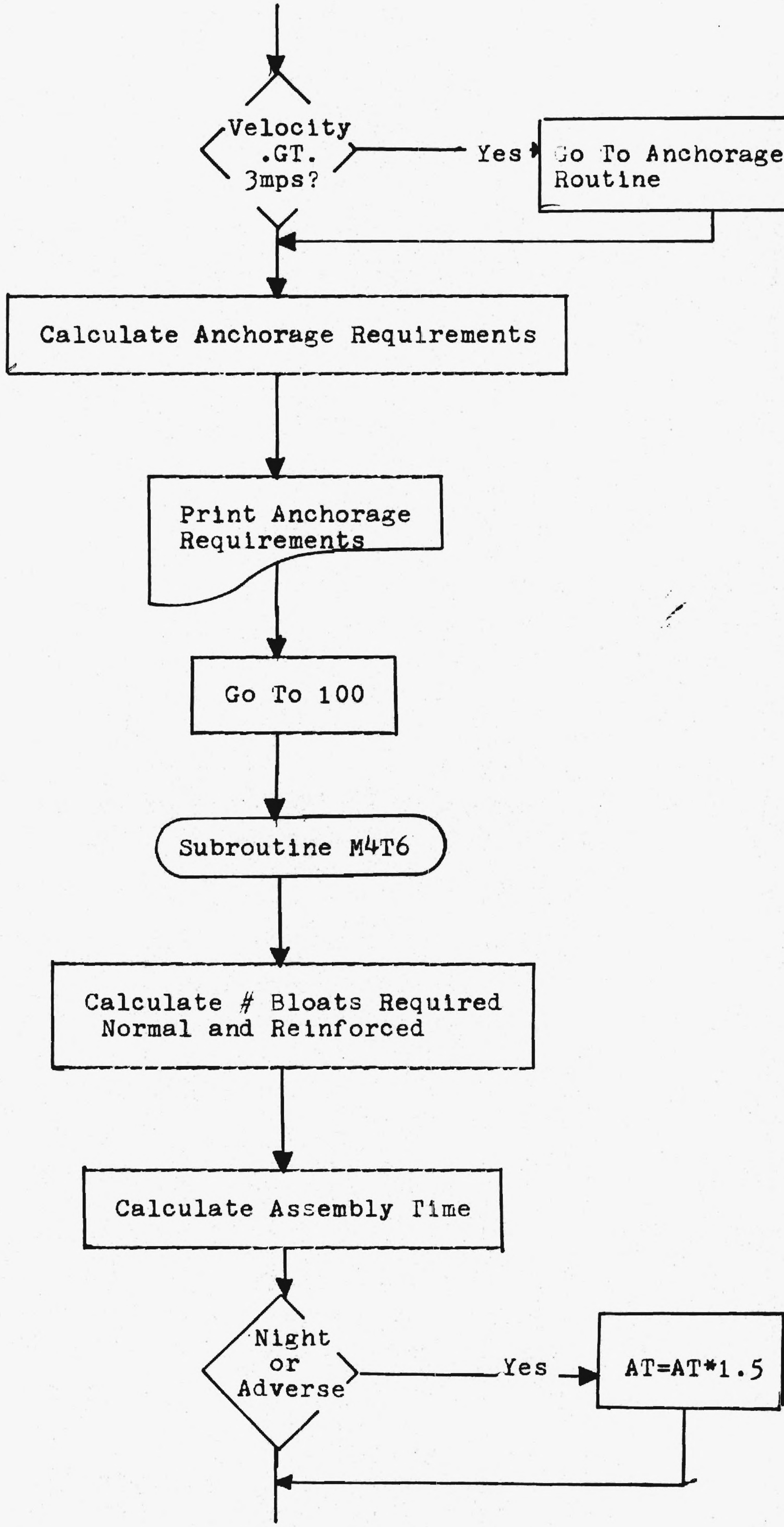

Input Type of Assets
To Be Used
Corps, Division, Other
Read Type of Assets To Be Used
If Corps Get Corps Assets
If Division Get Division Assets
If Other Ask For Bridge Assets
Read Bridge Assets
5
Select Type of Bridge
To Be Emplaced

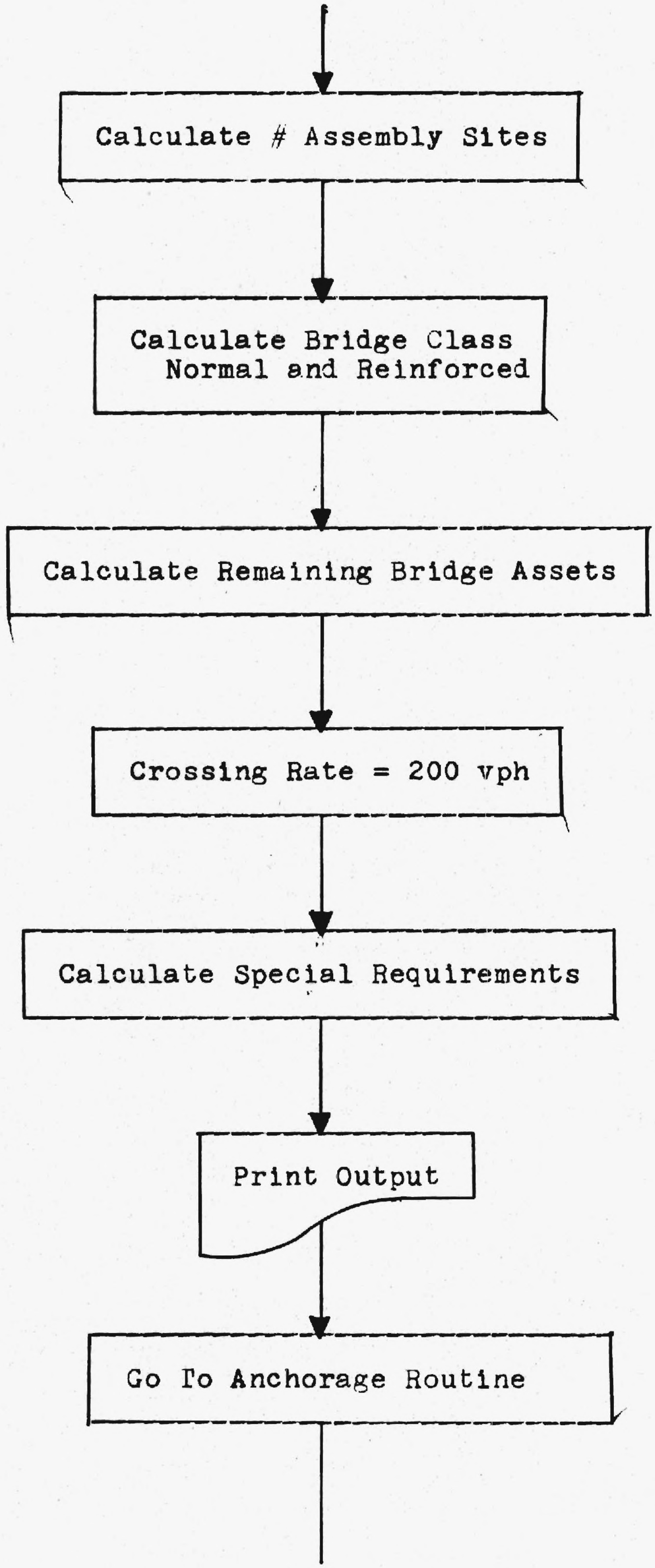


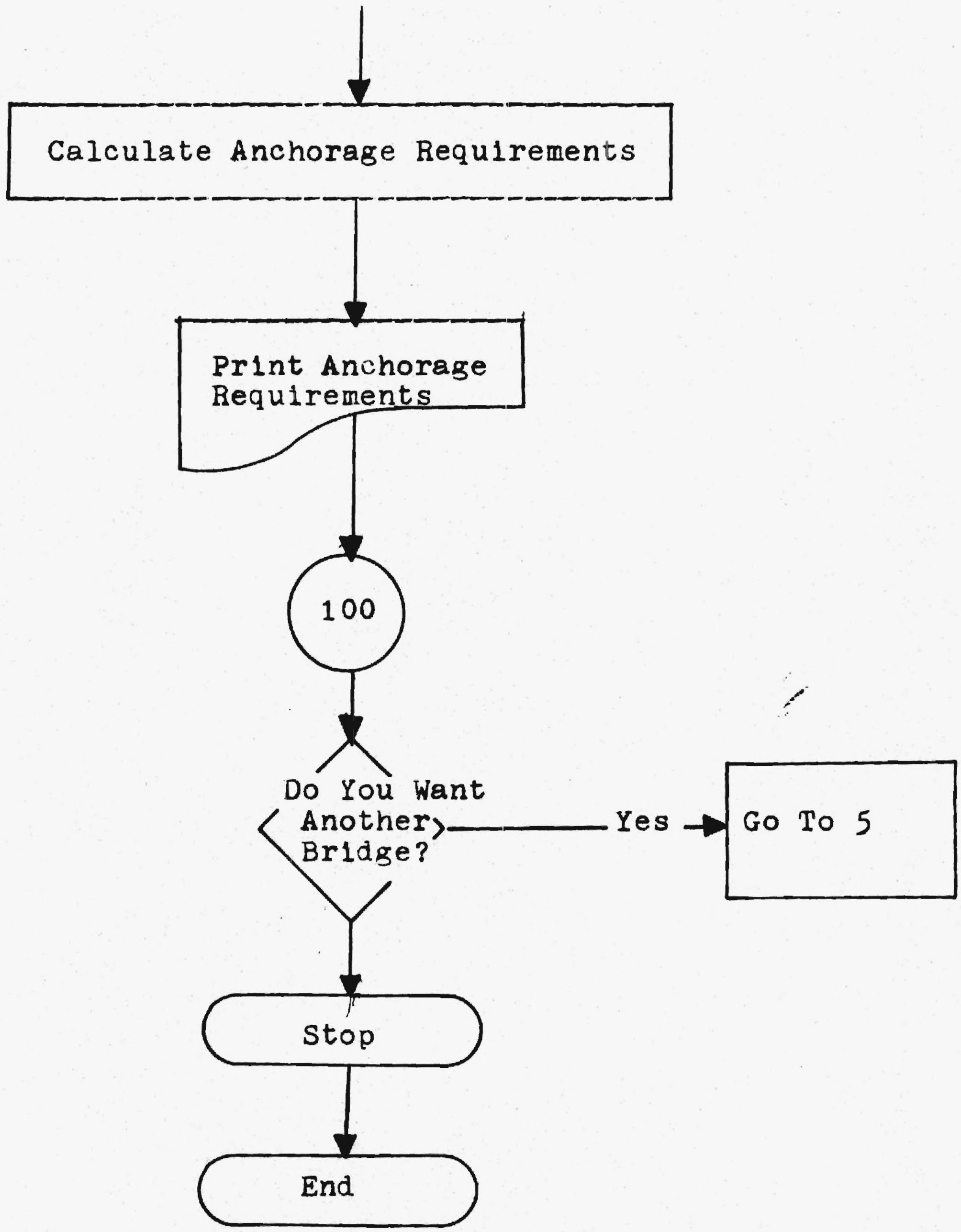
Read Bridge Type
Go To Appropriate Subroutine
Subroutine MAB
Retrieve Appropriate Bridging Assets
Calculate # Bays Required
Int = Gap(m)-20/8
End = 2
Calculate Assembly Time
Night or Adverse
Yes
AT=AT*1.5
Calculate Class


Crossing Rate = 200 vph
Calculate Remaining Bridge Assets
Int = Old - Intr
End = Old - 2
Print Output
This Bridge Requires
No Additional Anchorage
Go To 100
Subroutine Ribbon
Retrieve Appropriate Bridging Assets
Calculate # Bays Required


Calculate Assembly Time
Night or Adverse
Yes
AT=AT*/.5
Calculate Bridge Class
Crossing Rate = 200 vph
Calculate Remaining Assets
INT = Old - INTR
END = Old - 2
Required Assembly Sites = 3
BEB = 6
Print Output


Velocity .GT. 3mps?
Yes
Go To Anchorage Routine
Calculate Anchorage Requirements
Print Anchorage Requirements
Go To 100
Subroutine M4T6
Calculate # Bloats Required Normal and Reinforced
Calculate Assembly Time
Night or Adverse
Yes
AT=AT*1.5


Calculate # Assembly Sites
Calculate Bridge Class
Normal and Reinforced
Calculate Remaining Bridge Assets
Crossing Rate = 200 vph
Calculate Special Requirements
Print Output
Go To Anchorage Routine



Calculate Anchorage Requirements
Print Anchorage Requirements
100
Do You Want Another Bridge?
Yes
Go To 5
Stop
End

APPENDIX B

PROGRAM LISTING OF THE

PREFABRICATED FLOATING BRIDGE PROGRAM

```
      PROGRAM BEANER(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      INTEGER CW,CT,CR,AS,RIBI,RIBR,BEBR,AC,BD,BEBM,BEBMR,BEBMRR,CRAN
      INTEGER CTN,CWN,CTR,CWR,D7,CR,AIR,S1,CBR1,RIB
      DATA AYES/'YES'/,ANO/'NO'/,AMAB/'MAB'/,ARIBBON/'RIBBON'/
      DATA AM4T6/'M4T6'/,ACORPS/'CORPS'/,ADIV/'DIVI'/
      DATA AOTHER/'OTHER'/,ADAY/'DAY'/,ANIGHT/'NIGHT'/,AADVERS/
     + 'ADVERSE'/
C
C     SUBROUTINE INSTRUCTIONS
C
      PRINT(6,*)' '
      PRINT(6,*)'THIS IS A PROGRAM TO DESIGN A FLOATING BRIDGE AND
     +ANCHORAGE SYSTEM OF THE FOLLOWING TYPES'
      PRINT(6,*) '              MAB'
      PRINT(6,*) '              RIBBON'
      PRINT(6,*) '              M4T6'
      PRINT(6,*)' '
      PRINT(6,*) 'THE INPUT DATA REQUIRED TO MAKE THE APPROPRIATE
     +CALCULATIONS ARE AS FOLLOWS'
      PRINT(6,*)'      (A) RIVER WIDTH IN METERS'
      PRINT(6,*)'      (B) RIVER VELOCITY IN MPS'
      PRINT(6,*)'      (C) MEAN BANK HEIGHT IN METERS'
      PRINT(6,*)'      (D) RIVER DEPTH IN METERS'
      PRINT(6,*)'      (E) APPROACH AND EXIT SLOPE'
      PRINT(6,*)'      (F) SOIL CBR'
      PRINT(6,*)'      (G) BRIDGE ASSETS IN NON-STANDARD UNIT'
      PRINT(6,*)'      (H) ASSEMBLY CONDITIONS(DAY,NIGHT,ADVERSE)'
      PRINT(6,*)' '
      PRINT(6,*)'THE PROGRAM OUTPUT WILL CONSIST OF:'
      PRINT(6,*)'      (1) RIVER DATA'
      PRINT(6,*)'      (2) BRIDGE CLASS(WHEEL AND TRACK)'
      PRINT(6,*)'      (3) CROSSING RATE(VPH)'
      PRINT(6,*)'      (4) CONSTRUCTION TIME'
      PRINT(6,*)'      (5) REQUIRED ASSEMBLY SITES'
      PRINT(6,*)'      (6) REQUIRED BRIDGE ASSETS'
      PRINT(6,*)'      (7) REMAINING BRIDGE ASSETS'
      PRINT(6,*)'      (8) SPECIAL EQUIPMENT'
      PRINT(6,*)'      (9) ANCHORAGE REQUIREMENTS'
      PRINT(6,*)' '
      MAB=0
      RIB=0
      M4T6=0
C
C     SUBROUTINE INPUT
C
      DO 5 I=1,50
      PRINT(6,*)'ENTER THE RIVER WIDTH IN METERS'
      READ(5,*) W1
      PRINT(6,*)'ENTER THE RIVER VELOCITY IN MPS'
```

```
      READ(5,*) V1
      IF(V1.GT.3.5) GO TO 105
      PRINT(6,*)"ENTER THE RIVER DEPTH IN METERS"
      READ(5,*) D1
      IF(D1.LT.1.12) GO TO 110
      PRINT(6,*)"ENTER THE MEAN BANK HEIGHT IN METERS"
      READ(5,*) XMBH
      IF(XMBH.GT.1.5) BD=1
      PRINT(6,*)"ENTER THE MAX SLOPE OF APPROACH OR EXIT"
      READ (5,*) S1
      IF(S1.GT.20) BD=1
      PRINT(6,*)"ENTER SOIL CBR"
      READ(5,*) CBR1
      PRINT(6,*)"WHAT ARE ASSEMBLY CONDITIONS"
      PRINT(6,*)"ENTER DAY, NIGHT OR ADVERSE"
      READ(5,500) ANS
  500 FORMAT (A7)
      IF (ANS.EQ.ADAY) AC=1
      IF (ANS.EQ.ANIGHT) AC=2
      IF (ANS.EQ.AADVERS) AC=2
      PRINT(6,*)"ARE YOUR BRIDGING ASSETS:"
      PRINT(6,*)"(1)CORPS"
      PRINT(6,*)"(2)DIVISION"
      PRINT(6,*)"(3)OTHER"
      READ(5,501) ANS1
 501  FORMAT (A8)
      IF(ANS1.EQ.AOTHER) GO TO 50
      GO TO 160
   50 PRINT(6,*)"ENTER THE TYPE OF BRIDGE ASSETS YOU HAVE"
      READ(5,502) ANS3
 502  FORMAT (A7)
      IF(ANS3.EQ.AMAB) GO TO 51
      IF(ANS3.EQ.ARIBBON) GO TO 52
      IF(ANS3.EQ.3) GO TO 53
   51 PRINT(6,*)"ENTER # OF INTERIOR BAYS"
      READ(5,*) MABI
      PRINT(6,*)"ENTER NUMBER OF RAMP BAYS"
      READ(5,*) MABR
      GO TO 60
   52 PRINT(6,*)"ENTER # OF INTERIOR BAYS"
      READ(5,*) RIBI
      PRINT(6,*)"ENTER # OF RAMP BAYS"
      READ(5,*) RIBR
      PRINT(6,*)"ENTER # OF BRIDGE ERECTION BOATS"
      READ(5,*) BEBR
      GO TO 60
   53 PRINT(6,*)"ENTER # OF BRIDGE SETS"
      READ(5,*) M4T6S
      M4T6N=M4T6S*10
      M4T6R=M4T6S*10
      PRINT(6,*)"ENTER THE NUMBER OF BRIDGE ERRECTION BOATS"
```

```
          READ(6,*) BEBM
   60     PRINT(6,*)"DO YOU HAVE ADDITIONAL ASSETS YES OR NO"
          READ(5,601) AMSW
  601     FORMAT (A3)
          IF(AMSW.EQ.AYES) GO TO 50
          IF(AMSW.EQ.ANO) GO TO 160
  160     DO 6 K=1,50
          PRINT(6,*)"SELECT TYPE OF BRIDGE TO BE EMPLACED"
          PRINT(6,*)"ENTER MAB,RIBBON OR M4T6"
          READ(5,505) BRIDGE
  505     FORMAT (A7)
          IF(BRIDGE.EQ.AMAB) GO TO 250
          IF(BRIDGE.EQ.ARIBBON) GO TO 260
          IF(BRIDGE.EQ.AM4T6) GO TO 270
C
C                            SUBROUTINE MAB
C
  250 MAB=MAB+1
      IF(MAB.GT.1) GO TO 253
      GO TO 2051
  253 PRINT(6,*)"YOU HAVE ALREADY CALCULATED A MAB DO YOU WISH TO USI
      PRINT(6,*)"YOUR REMAINING ASSETS AS THE BASE TO CALCULATE FROM
      PRINT(6,*)"OR DO YOU WISH A FULL COMPLIMENT OF BRIDGING ASSETS
      PRINT(6,*)"ENTER YES IF YOU WANT TO USE YOUR REMAINING ASSETS"
      PRINT(6,*)"ENTER NO IF YOU WANT A FULL COMPLIMENT OF ASSETS"
      READ(5,2049) ANS5
 2049 FORMAT (A3)
      IF(ANS5.EQ.AYES) GO TO 254
 2051 IF(ANS1.EQ.ACORPS) GO TO 251
      IF(ANS1.EQ.ADIV) GO TO 252
      GO TO 255
  251 MABI=24
      MABR=12
      IF(W1.GT.212.) GO TO 99
      GO TO 255
  252 MABI=16
      MABR=8
      IF(W1.GT.149.) GO TO 99
      GO TO 255
  254 MABI=NMABI
      MABR=NMABR
  255 XMABINT=(W1-20.)/8.
      MABINT=XMABINT
      MABRP=2
      AT=W1/200.
      IF(AC.EQ.1) AT=AT
      IF(AC.EQ.2) AT=AT*1.5
      IF(V1.LT.2.) CW=62
      IF(V1.GE.2.0) CW=55
      CT=CW
      CR=200
```

```
      NMABI=MABI-MABINT
      NMABR=MABR-2
      AS=1
      IF(NMABI.LT.0) GO TO 99
      IF(NMABR.LT.0) GO TO 99
      PRINT(6,*)"              MOBILE ASSAULT BRIDGE"
      PRINT(6,*) " "
      PRINT(6,*) " "
      PRINT(6,*)"RIVER DATA:"
      PRINT(6,40) W1
   40 FORMAT(15X,"WIDTH",F5.0," METERS")
      PRINT(6,41) V1
   41 FORMAT(15X,"VELOCITY",F5.2," MPS")
      PRINT(6,42) D1
   42 FORMAT(15X,"DEPTH",F5.2," METERS")
      PRINT(6,*) " "
      PRINT(6,*)"BRIDGE DATA"
      PRINT(6,*)"                                       REQUIRED      REMAINING
      PRINT(6,*)" CLASS   RATE    CO    ASS      ASSETS           ASSETS"
      PRINT(6,*)"  W  T    VPH    HRS   SITES    INT   RMP       INT   RMP
      PRINT(6,44)CW,CT,CR,AT,AS,MABINT,MABRP,NMABI,NMABR
   44 FORMAT(3X,I2,1X,I2,3X,I3,3X,F4.1,5X,I2,5X,I2,4X,I2,5X,I2,4X,I2)
      PRINT(6,*) " "
      PRINT(6,*)"            SPECIAL REQUIREMENTS"
      PRINT(6,*)" "
      IF(CBR1.LT.10) GO   TO 45
      GO TO 46
   45 PRINT(6,*)"SOIL REQUIRES STABILIZATION"
   46  IF(BD.EQ.1) GO TO 461
      GO TO 472
  461 PRINT(6,47) BD
   47 FORMAT(I2," BULDOZERS REQUIRED FOR SITE PREPARATION")
  472 PRINT(6,*)" "
      PRINT(6,*)"         ANCHORAGE REQUIREMENTS"
      PRINT(6,*)" "
      PRINT(6,*) "THIS BRIDGE REQUIRES NO ADDITIONAL ANCHORAGE"
      PRINT(6,*)" "
      GO TO 100
C
C                 SUBROUTINE RIBBON
C
  260 RIB=RIB+1
      IF(RIB.GT.1) GO TO 263
      GO TO 2066
  263 PRINT(6,*)"YOU HAVE ALREADY CALCULATED A RIBBON BRIDGE, DO YOU"
      PRINT(6,*)"WISH TO USE YOUR REMAINING ASSETS AS THE BASE TO "
      PRINT(6,*)"CALCULATE FROM OR DO YOU WISH A FULL COMPLIMENT OF BR
     +GING ASSETS"
      PRINT(6,*)"ENTER YES IF YOU WISH TO USE YOUR REMAINING ASSETS"
      PRINT(6,*)"ENTER NO IF YOU WISH A FULL COMPLIMENT OF ASSETS"
      READ(5,2067) ANSR
```

```
 2067 FORMAT (A3)
      IF(ANSR.EQ.AYES) GO TO 2063
 2066 IF(ANS1.EQ.ACORPS) GO TO 261
      IF(ANS1.EQ.ADIV) GO TO 262
      GO TO 265
  261 RIBI=30
      RIBR=12
      BEBR=14
      IF(W1.GT.213.) GO TO 99
      GO TO 265
  262 PRINT(6,*)'THERE ARE NO RIBBON BRIDGE ASSETS AT DIVISION LEVEL
      GO TO 100
 2063 RIBI=NRIBI
      RIBR=NRIBR
      BEBR=NBEBR
  265 RIBINT=(W1-14.)/6.7
      IRIBINT=RIBINT+1
      IRIBR=2
      IF(W1.LT.75)   GO TO 701
      IF(W1.LT.160) GO TO 702
      IF(W1.LT.300) GO TO 703
  701 AT=.5
      GO TO 705
  702 AT=.75
      GO TO 705
  703 AT=1.75
      GO TO 705
  705 IF(AC.EQ.1) AT=AT
      IF(AC.EQ.2) AT=AT*1.5
      IF(V1.LT.2.5) CW=60
      IF(V1.GE.2.5) CW=45
      CT=CW
      CR=200
      NRIBI=RIBI-RIBINT
      NRIBR=RIBR-2
      IF(NRIBI.LT.0) GO TO 99
      IF(NRIBR.LT.0) GO TO 99
      AS=3
      IBEBRR=6
      IF(BEBR.LT.IBEBRR) GO TO 266
      GO TO 267
  266 PRINT(6,*)'INSUFFICIENT BRIDGE ERRECTION BOATS AVAILABLE'
  267 IF(V1.GT.3.) GO TO 268
      IBEBR=RIBINT/4.+1
      NBEBR=BEBR-IBEBR
  268 BEB=0
      PRINT(6,*)'                         RIBBON BRIDGE'
      PRINT(6,*) ' '
      PRINT(6,*)' '
      PRINT(6,*)'RIVER DATA'
      PRINT(6,600) W1
```

```
  600 FORMAT(15X,"WIDTH",F5.0," METERS")
      PRINT(6,61) V1
   61 FORMAT(15X,"VELOCITY",F5.2," MPS")
      PRINT(6,62) D1
   62 FORMAT(15X,"DEPTH",F5.2," METERS")
      PRINT(6,*)" "
      PRINT(6,*) "BRIDGE DATA"
      PRINT(6,*)"                                    REQUIRED      REMAINING"
      PRINT(6,*)"  CLASS    RATE    CO     ASS     ASSETS          ASSETS"
      PRINT(6,*)"   W  T    VPH     HRS   SITES  INT  RMP  BEB    INT  RMP
     +BEB"
      PRINT(6,280) CW,CT,CR,AT,AS,IRIBINT,IRIBR,IBEBR,NRIBI,NRIBR,NBEB
  280 FORMAT(4X,I2,1X,I2,3X,I3,3X,F4.1,4X,I1,4X,I2,3X,I2,3X,I2,4X,I2,3
     +,I2,3X,I2,3X,I2)
      PRINT(6,*) " "
      PRINT(6,*)"                    SPECIAL REQUIREMENTS"
      PRINT(6,*)" "
      IF(CBR1.LT.10) GO TO 81
      GO TO 82
   81 PRINT(6,*) "THIS SOIL REQUIRES STABILIZATION"
   82 IF(BD.EQ.1) GO TO 83
      GO TO 85
   83 PRINT(6,84) BD
   84 FORMAT(I2," BULDOZERS REQUIRED FOR SITE PREPARARTION")
   85 PRINT(6,*) " "
      PRINT(6,*)" "
      PRINT(6,*)"                   ANCHORAGE REQUIREMENTS"
      PRINT(6,*)" "
      IF(V1.GT.3.) GO TO 269
      PRINT(6,281) IBEBR
  281 FORMAT("ANCHORAGE CONSISTS OF",I3," BRIDGE ERRECTION BOATS")
      PRINT(6,*)"PLACED EVERY FOURTH BAY"
      PRINT(6,*)" "
      GO TO 100
  269 PRINT(6,*)" ANCHORAGE CALCULATED BY ANCHORAGE SUBROUTINE"
      PRINT(6,*)" "
      GO TO 100
C
C       SUBROUTINE M4T6
C
  270 M4T6=M4T6+1
      IF(M4T6.GT.1) GO TO 273
      GO TO 2071
  273 PRINT(6,*) "YOU HAVE ALREADY CALCULATED A M4T6 BRIDGE, DO YOU"
      PRINT(6,*)"WISH TO USE YOUR REMAINING ASSETS AS THE BASE TO"
      PRINT(6,*)"CALCULATE FROM, OR DO YOU WICH A FULL COMPLIMENT OF B
     +DGING ASSETS"
      PRINT(6,*)" ENTER YES IF YOU WISH TO USE YOUR REMAINING ASSETS"
      PRINT(6,*)"ENTER NO IF YOU WISH A FULL COMPLIMENT OF ASSETS"
      READ(5,2075) ANSM
 2075 FORMAT (A3)
```

```
      IF(ANSM.EQ.AYES) GO TO 2073
 2071 IF (ANS1.EQ.ACORPS) GO TO 271
      IF(ANS1.EQ.ADIV) GO TO 272
      IF(ANS1.EQ.AOTHER) GO TO 275
  271 M4T6N=50
      M4T6R=50
      BEBM=10
      IF(W1.GT.213.) GO TO 99
      GO TO 275
  272 M4T6N=40
      M4T6R=40
      BEBM=8
      IF(W1.GT.171.) GO TO 99
      GO TO 275
 2073 M4T6N=NM4T6N
      M4T6R=NM4T6R
      BEBM=NBEBM
  275 XM4T6N=(W1/4.6+2.)*1.1
      XM4T6R=(W1/3.)*1.1
      M4T6NR=XM4T6N
      M4T6RR=XM4T6R
      IF(W1.LT.75.) GO TO 301
      IF(W1.LT.160.) GO TO 302
      IF(W1.LT.300.) GO TO 303
  301 AT=6
      AS=2
      GO TO 310
  302 AT=12
      AS=5
      GO TO 310
  303 AT=20
      AS=6
      GO TO 310
  310 IF(AC.EQ.1) AT=AT
      IF(AC.EQ.2) AT=AT*1.5
      ATP=AT*3
       IF(V1.LT.1.5) GO TO 315
      IF(V1.LT.2.) GO TO 316
      IF(V1.LT.2.5) GO TO 317
      IF(V1.LT.3.5) GO TO 318
  315 CTN=45
      CWN=55
      CTR=75
      CWR=75
      GO TO 320
  316 CTN=40
      CWN=50
      CTR=70
      CWR=75
      GO TO 320
  317 CTN=35
```

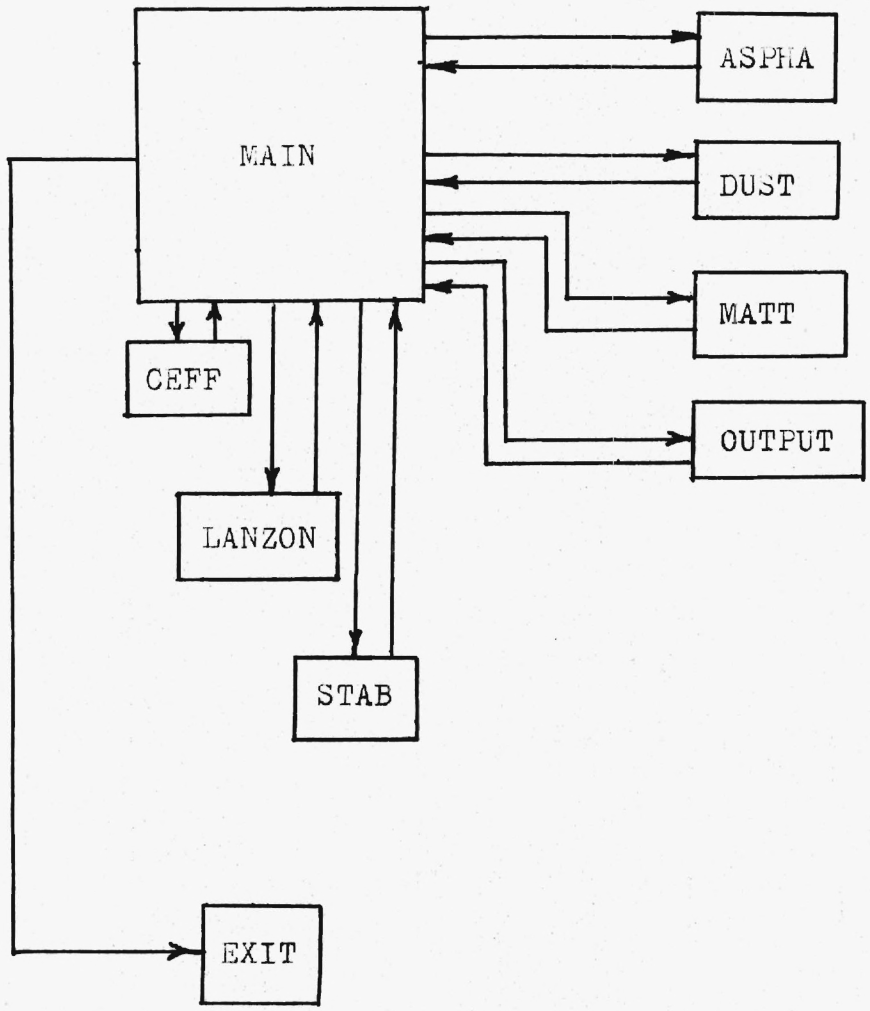
```
      CTR=65
      CWN=45
      CWR=70
      GO TO 320
  318 CTN=25
      CWN=30
      CTR=27
      CWR=30
      GO TO 320
  320 NM4T6N=M4T6N-M4T6NR
      NM4T6R=M4T6R-M4T6RR
      IF(NM4T6R.LT.0) GO TO 99
      IF(NM4T6N.LT.0) GO TO 99
      CR=200
      D7=2+BD1
      CRANE=1*AS
      AIR=2*AS
      BEBMR=2*AS
      BEBM=BEBM-BEBMR
      PRINT(6,*)"                M4T6 FLOATING BRIDGE"
      PRINT(6,*)" "
      PRINT(6,*)" "
      PRINT(6,*)"RIVER DATA"
      PRINT(6,350) W1
  350 FORMAT(15X,"WIDTH",F5.0,"METERS")
      PRINT(6,351) V1
  351 FORMAT(15X,"VELOCITY",F5.2,"MPS")
      PRINT(6,352) D1
  352 FORMAT(15X,"DEPTH",F5.2,"METERS")
      PRINT(6,*)" "
      PRINT(6,*)"BRIDGE DATA"
      PRINT(6,*)"CLASS   RATE   CO   PLT   ASS   REQUIRED  REMAINING
      PRINT(6,*)" W  T   VPH   HRS   HRS  SITES  FLTS BEB  FLTS  BEB
      PRINT(6,353) CTN,CWN,CR,AT,ATP,AS,M4T6NR,BEBMR,NM4T6N,BEBM
  353 FORMAT(2X,I2,1X,I2,2X,I3,3X,F4.1,2X,F4.1,4X,I1,5X,I2,2X,I2,3X,:
     +3X,I2," FOR NORMAL BRIDGE")
      PRINT(6,354) CTR,CWR,CR,AT,ATP,AS,M4T6RR,BEBMR,NM4T6R,BEBM
  354 FORMAT(2X,I2,1X,I2,2X,I3,3X,F4.1,2X,F4.1,4X,I1,5X,I2,2X,I2,3X,:
     +3X,I2," FOR REINFORCED BRIDGE")
      PRINT(6,*) " "
      PRINT(6,*)"            SPECIAL REQUIREMENTS"
      PRINT(6,*)" "
      IF(CBR1.LT.10) GO TO 3541
      GO TO 3542
 3541 PRINT(6,*)"THIS SOIL REQUIRES STABILIZATION"
 3542 PRINT(6,355) D7
  355 FORMAT(5X,I2," BULDOZERS ARE REQUIRED FOR SITE PREPARATION")
      PRINT(6,356) CRANE
  356 FORMAT(5X,I2," CRANES ARE REQUIRED, ONE AT EACH ASSEMBLY SITE"
      PRINT(6,357) AIR
  357 FORMAT(5X,I2," AIR COMPRESSORS ARE REQUIRED,TWO AT EACH ASSEMB:
```

```
     + SITE")
      PRINT(6,358) BEBMR
  358 FORMAT(5X,I2,"BRIDGE ERECTION BOATS ARE REQUIRED")
      PRINT(6,*)" "
      PRINT(6,*) "                    ANCHORAGE REQUIREMENTS"
      PRINT(6,*) " "
      PRINT(6,*)"ANCHORAGE REQUIREMENTS CALCULATED BY ANCHORAGE SUBROU
     +NE"
      PRINT(6,*)
      GO TO 100
C
C     SUBROUTINE EXIT
C
   99 PRINT(6,*)"YOU HAVE INSUFFICIENT BRIDGING ASSETS"
  100 PRINT(6,*)"DO YOU WANT TO DO ANOTHER BRIDGE,YES OR NO"
      READ(5,590) ANSW1
  590 FORMAT (A3)
      IF(ANSW1.EQ.AYES) GO TO 101
      GO TO 999
  101 PRINT(6,*)"DO YOU HAVE NEW INPUT,YES OR NO"
      READ (5,591) ANSW2
  591 FORMAT (A3)
      IF(ANSW2.EQ.AYES) GO TO 5
    6 CONTINUE
  105 PRINT(6,*)"THE CURRENT IS TO FAST, TRY TACTICAL FIXED BRIDGING"
      GO TO 1000
  110 PRINT(6,*)"THE RIVER HAS INSUFFICIENT DEPTH, TRY FORDING"
 1000 PRINT(6,*)"DO YOU HAVE NEW INPUT YES OR NO"
      READ(5,592) ANSW3
  592 FORMAT (A3)
      IF(ANSW3.EQ.ANO) GO TO 999
    5 CONTINUE
  999 STOP
      END
```

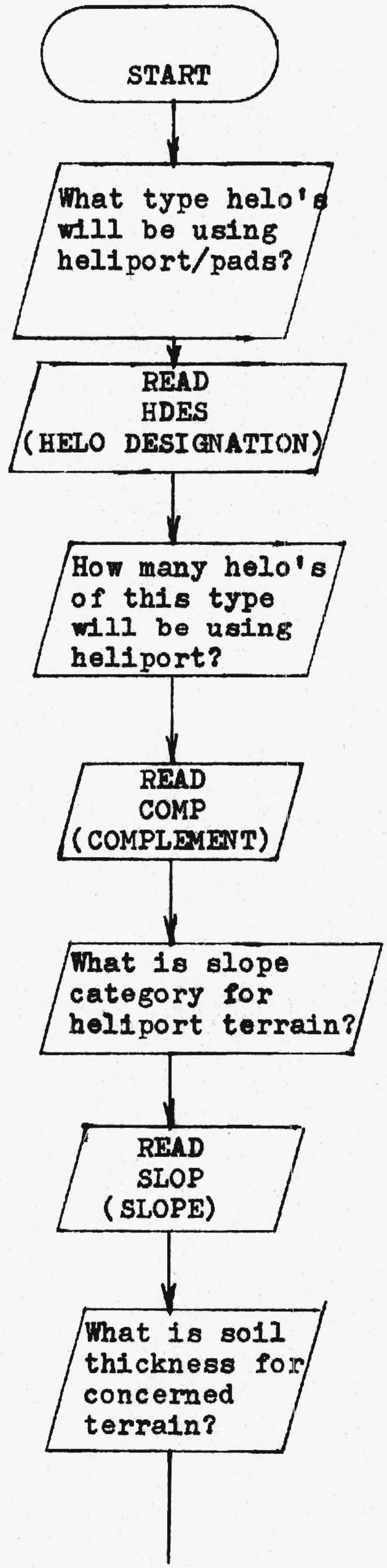
APPENDIX C

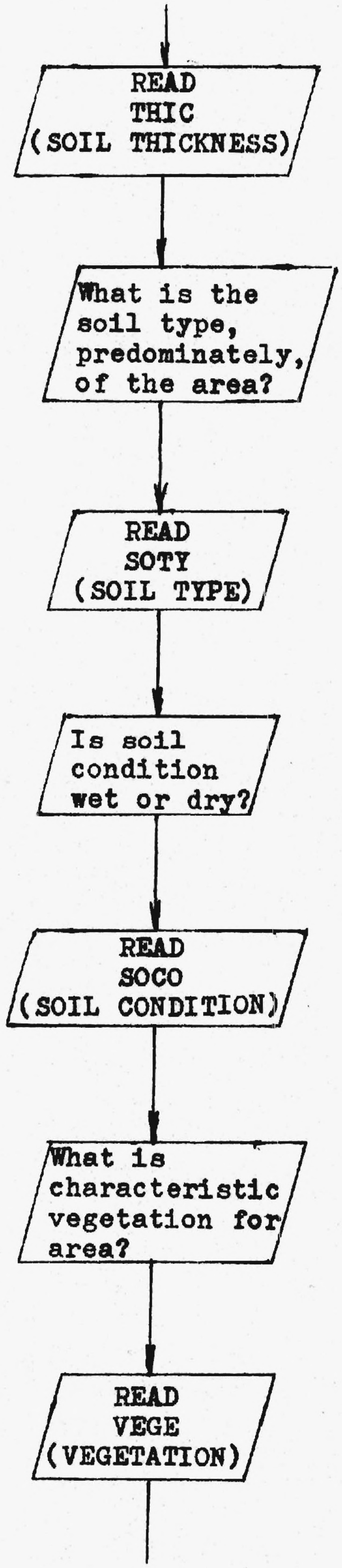
DETAILED FLOW CHARTS FOR THE HELO PROGRAM

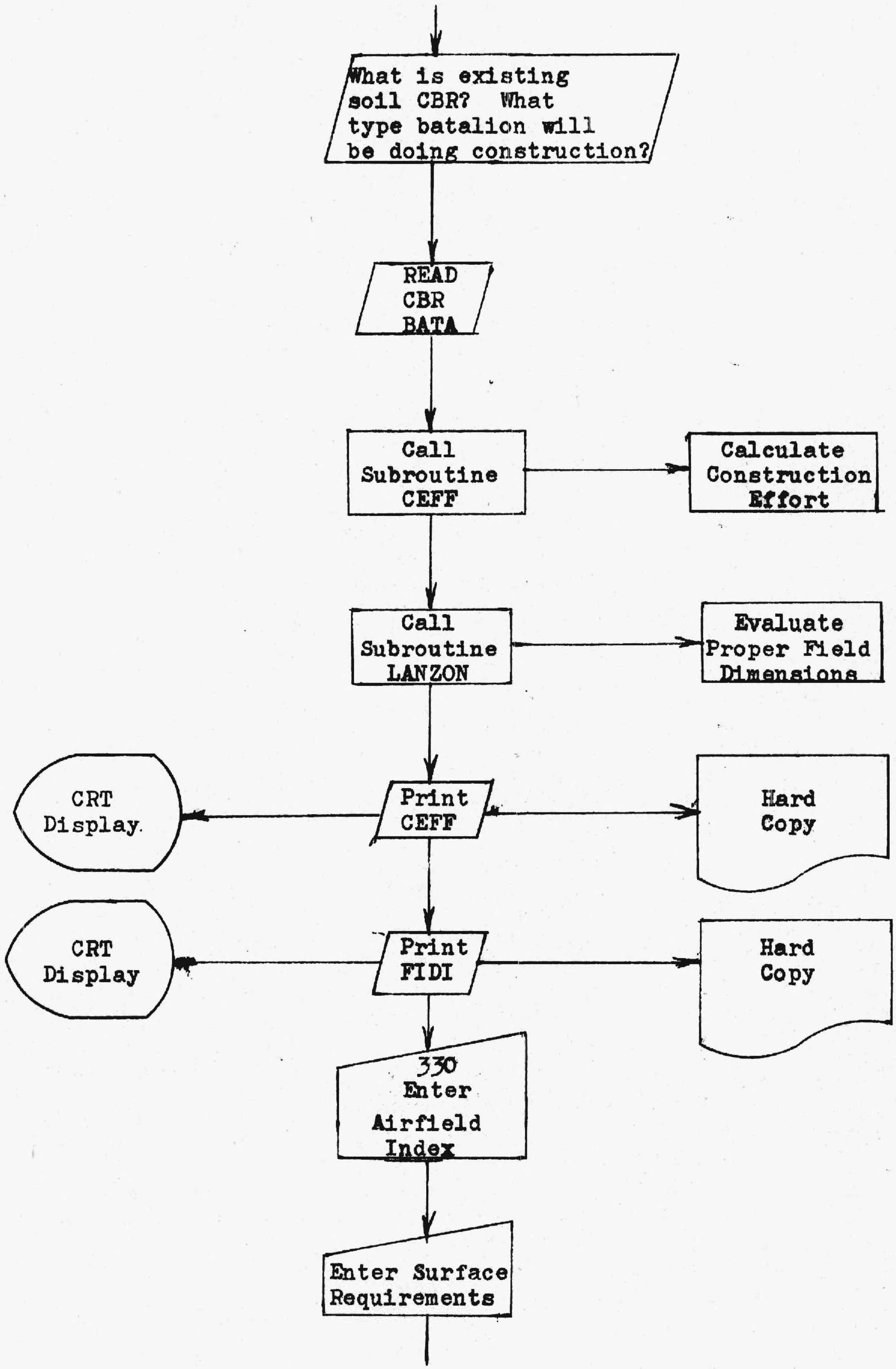
SUBROUTINE FLOW CHART

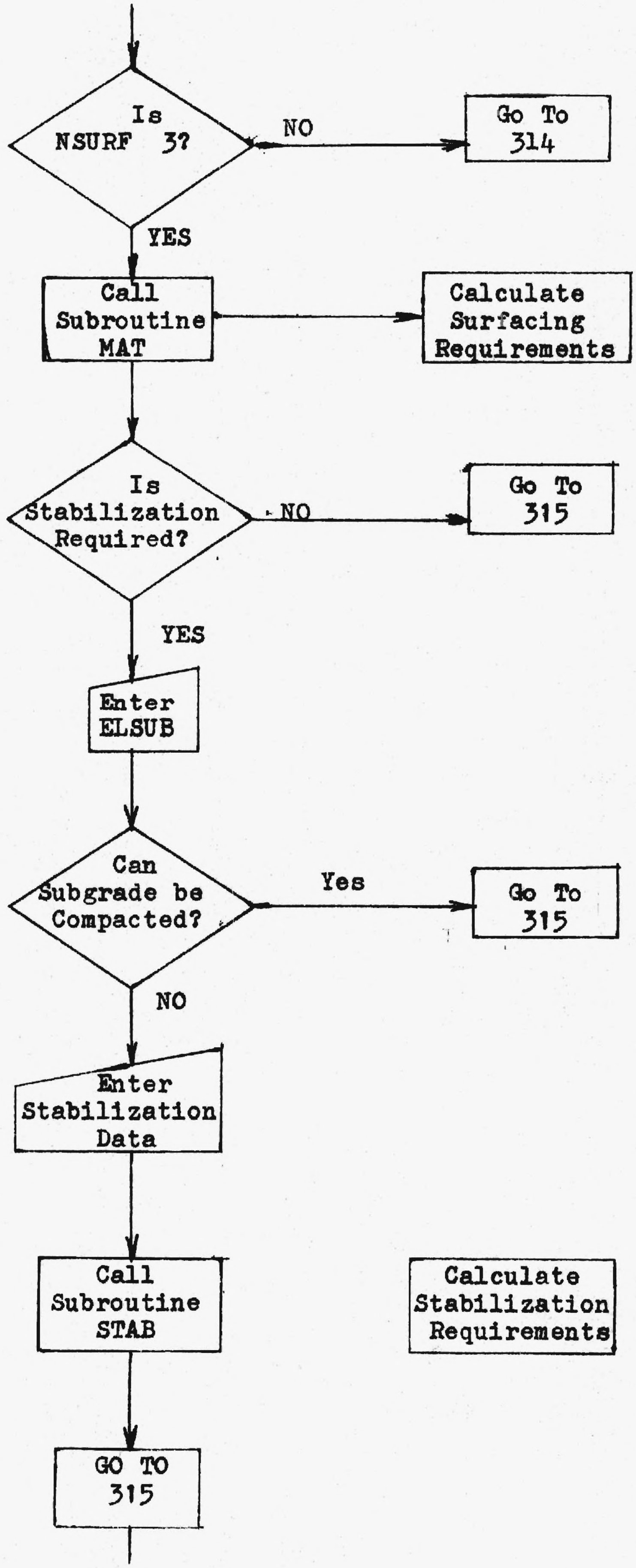


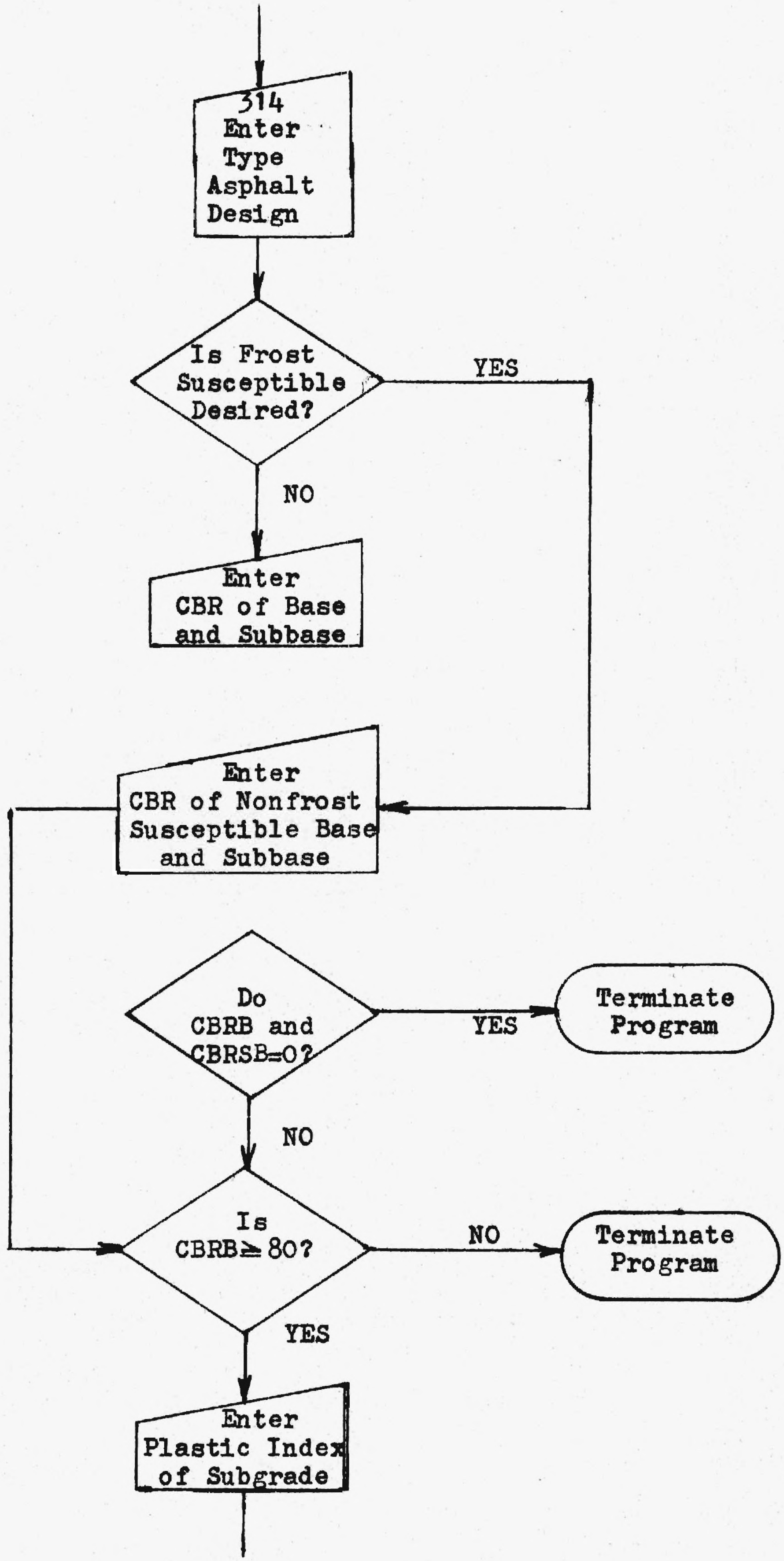
FLOW CHART


START
What type helo's will be using heliport/pads?
READ HDES (HELO DESIGNATION)
How many helo's of this type will be using heliport?
READ COMP (COMPLEMENT)
What is slope category for heliport terrain?
READ SLOP (SLOPE)
What is soil thickness for concerned terrain?

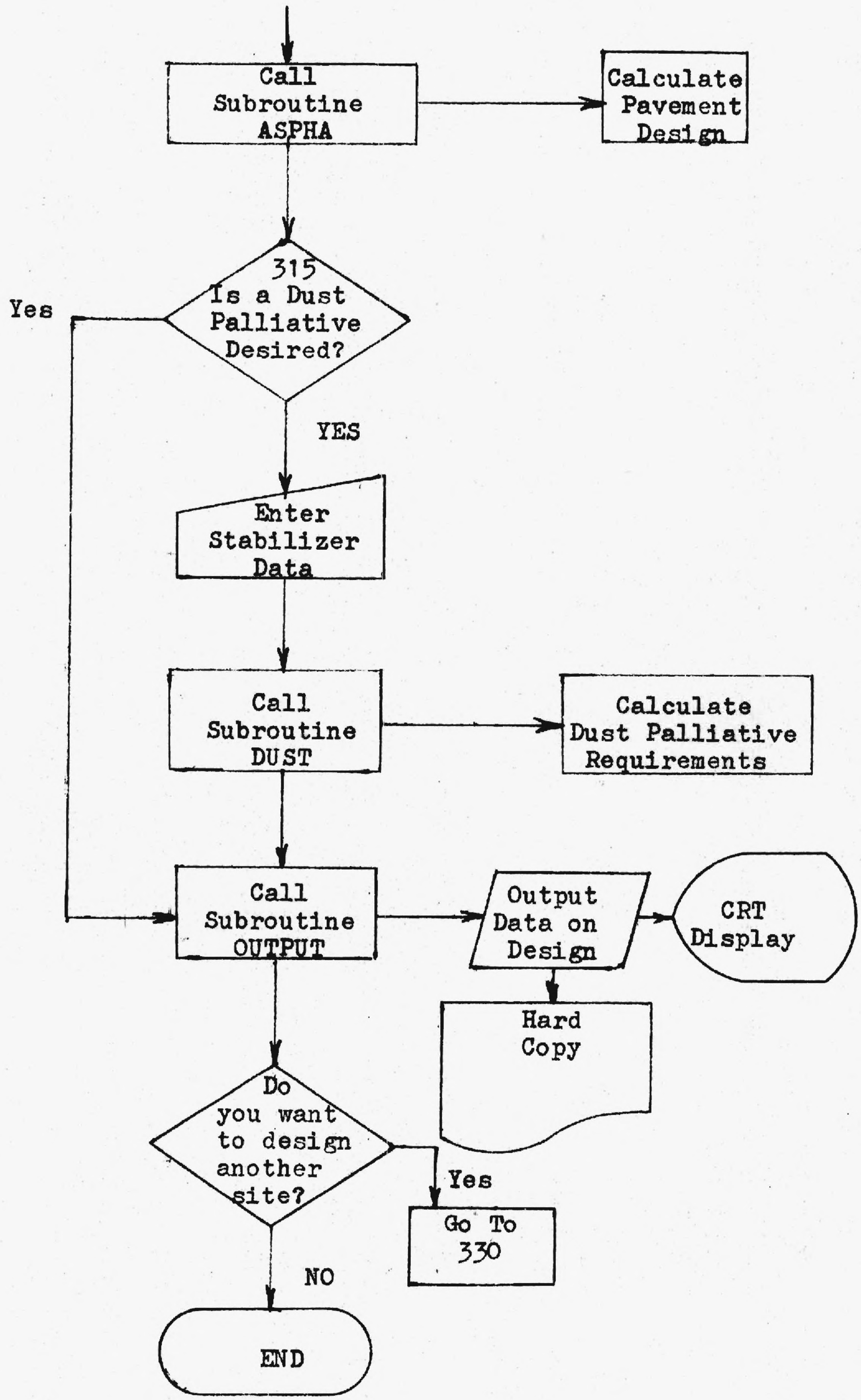

READ THIC (SOIL THICKNESS)
What is the soil type, predominately, of the area?
READ SOTY (SOIL TYPE)
Is soil condition wet or dry?
READ SOCO (SOIL CONDITION)
What is characteristic vegetation for area?
READ VEGE (VEGETATION)


What is existing soil CBR? What type batalion will be doing construction?
READ CBR BATA
Call Subroutine CEFF
Calculate Construction Effort
Call Subroutine LANZON
Evaluate Proper Field Dimensions
CRT Display
Print CEFF
Hard Copy
CRT Display
Print FIDI
Hard Copy
330 Enter Airfield Index
Enter Surface Requirements


Is NSURF 3?
NO
Go To 314
YES
Call Subroutine MAT
Calculate Surfacing Requirements
Is Stabilization Required?
NO
Go To 315
YES
Enter ELSUB
Can Subgrade be Compacted?
Yes
Go To 315
NO
Enter Stabilization Data
Call Subroutine STAB
Calculate Stabilization Requirements
GO TO 315



314
Enter
Type
Asphalt
Design
Is Frost
Susceptible
Desired?
YES
NO
Enter
CBR of Base
and Subbase
Enter
CBR of Nonfrost
Susceptible Base
and Subbase
Do
CBRB and
CBRSB=0?
YES
Terminate
Program
NO
Is
CBRB≥80?
NO
Terminate
Program
YES
Enter
Plastic Index
of Subgrade


Call Subroutine ASPHA
Calculate Pavement Design
315 Is a Dust Palliative Desired?
Yes
YES
Enter Stabilizer Data
Call Subroutine DUST
Calculate Dust Palliative Requirements
Call Subroutine OUTPUT
Output Data on Design
CRT Display
Hard Copy
Do you want to design another site?
Yes
Go To 330
NO
END

APPENDIX D

USER'S MANUAL FOR THE HELO PROGRAM

USER'S MANUAL

After properly logging on the computer, and directing the program to execute, the following operations will occur:

STEP 1

The computer will ask if you have a file input. Answer "yes" or "no" after the computer prints a question mark and hit "return". ... see TAB A of the user's manual for file preparation. If "yes" was entered, go to step 12.

```
DO YOU HAVE A FILE INPUT?
? NO
```

STEP 2

The computer will ask what type heliport is to be designed, forward area or support area. Type the proper integer response and hit "return".

```
WHAT TYPE HELIPORT IS TO BE DESIGNED, FORWARD
 AREA OR SUPPORT AREA ?
 IF FORWARD, ENTER 0 ... IF SUPPORT, ENTER 1.
? 0
```

STEP 3

The computer will now advise you of the data it requires to perform the program. First addressed are the type and complement of helicopters. There are four classifications of the types of helicopters:

1. OH-6, OH-13, OH-23
2. UH-1, AH-1, AH-56, OH-58
3. UH-19, CH-34, CH-46, CH-47
4. CH-37, CH-53, CH-54, CH-25.

The computer will ask for the number of each type aircraft to be using the heliport. It will advise you to enter figures in the form of 9x if a company, or companies, of helicopters is involved. If a mixture,(i.e., more than one company, but less than two) enter the exact number. Anything less than one company, enter the exact number. After entering the number, hit "return".

```
YOU ARE NOW READY TO ENTER DATA PERTAINING
 TO HELICOPTER TYPES AND QUANTITIES.  TYPE ONE (1)
 HELICOPTERS ARE THE OH-6, OH-13, AND/OR OH-23.
 ENTER THE TOTAL NUMBER OF TYPE ONE HELICOPTERS ARE
 EXPECTED TO USE THE HELIPORT.
 ***NOTE***  IF THERE IS TO BE A COMPANY OF HELICOPTERS,
 ENTER 91, - TWO COMPANIES, 92, - THREE COMPANIES,93 -
 AND SO ON.  IF LESS THAN ONE COMPANY, ENTER THE
 SPECIFIC NUMBER.
? 6

TYPE TWO (2) HELICOPTERS INCLUDE THE UH-1,
 AH-1, AH-56, AND/OR OH-58.  ENTER THE NUMBER OF
 TYPE TWO HELICOPTERS IN THE SAME MANNER AS ABOVE.
? 0

TYPE THREE (3) HELICOPTERS INCLUDE THE UH-19,
 CH-34, CH-46, AND/OR CH-47.  ENTER THE NUMBER OF
 TYPE THREE HELICOPTERS IN THE SAME MANNER.
? 8

TYPE FOUR (4) HELICOPTERS INCLUDE THE CH-25,
 CH-37, CH-53, AND/OR CH-54.  ENTER THE NUMBER
 OF TYPE FOUR HELICOPTERS IN THE SAME MANNER.
? 8
```

STEP 4

The computer will now print, in a tabular form, a summary of the data you just input. You will be asked to check and confirm the accuracy of the data. If there are no errors, answer the prompting question "yes"; if there are errors respond "no". If "yes" is typed in, go to step 5.

```
AS A CHECK ON YOUR HELICOPTER DATA INPUT, YOUR
 DATA WILL BE TABULATED AND PRINTED.  CHECK AND CONFIRM
 THESE VALUES.
```

HELICOPTER TYPE	NO. OF INDIVIDUAL HELICOPTERS	NO. OF COMPANIES
1	6.	0
2	0.	0
3	8.	0
4	8.	0

```
IS THE PRINTED DATA EQUIVALENT TO THE DATA
 YOU INPUT?
? YES
```

STEP 5

As a mistake has been made, the computer will ask you how many errors there are. (There can be 1 to 4 errors as there are 4 types of helicopters.) Type in the number of errors and hit "return". The computer will then ask under what type helicopter the errors occur, by error. After the corrections are completed, the computer will return to step 3.

```
IS THE PRINTED DATA EQUIVALENT TO THE DATA            YOU INPUT?
? NO

HOW MANY ERRORS ARE THERE?
? 2

ERROR 1 OCCURS ON WHICH HELICOPTER              TYPE?
? 1

TYPE IN THE CORRECTED VALUE AS PER PREVIOUS            INPUT INSTRUCTIONS.
? 6

ERROR 2 OCCURS ON WHICH HELICOPTER              TYPE?
? 3

TYPE IN THE CORRECTED VALUE AS PER PREVIOUS            INPUT INSTRUCTIONS.
? 91
```

STEP 6

The computer will now ask you how many heliports you wish to compare. Answer the question with an integer from 1 to 10, and hit "return".

```
HOW MANY HELIPORTS ARE TO BE COMPARED (1-10)?
? 1
```

STEP 7

The computer will define the inputs necessary for characterization of the terrain. Each characteristic will correspond to a numerical entry. Type in the appropriate number to the prompting question and hit "return". The inputs to be made are slope, soil thickness and soil type for each heliport.

```
YOU ARE NOW READY TO INPUT VARIOUS TERRAIN

CHARACTERISTICS FOR THE HELIPORT OF CONCERN.
 SLOPE CHARACTERISTICS, SOIL THICKNESS AND SOIL TYPE
 WILL BE READ.  IF THE SLOPE IS LESS THAN 2%, ENTER
 1 - IF IT RANGES FROM 2 TO 10%, ENTER 2 - IF IT
 RANGES FROM 10 TO 30%, ENTER 3 - IF RENGE IS 30 TO
 40, ENTER 4 - IF GREATER THAN 40%, ENTER 9.

FOR SOIL THICKNESS, IF THE SOIL IS LESS THAN 2 FEET
 THICK, ENTER 1 - IF RANGE IS 2 TO 20 FEET, ENTER 2 -
 IF THICKER THAN 20 FEET,ENTER 3.

FOR SOIL TYPES, IF SAND,ENTER 1 - SILT, ENTER 2 -
 CLAY, ENTER 3 - LATERITE (SOFT), ENTER 4 - ROCK/
 LATERITE (HARD), ENTER 5.


FOR HELIPORT  1
 SLOPE:
? 2
 SOIL THICKNESS:
? 1
 SOIL TYPE:
? 3
```

STEP 8

The computer will continue asking for soil inputs. Type in the appropriate integer corresponding to the terrain characteristics, and hit "return". The inputs to be made include soil condition, CBR and vegetation.

```
NOW INPUT THE SOIL CONDITION, CBR, AND VEGETATION
 IF THE SOIL IS DRY, ENTER 1 - IF WET, ENTER 2.
 ENTER THE CBR DIRECTLY.
 FOR VEGETATION,  IF THE LAND IS BARREN, ENTER 1
 GRASS OR LARGE CULTIVATED FIELDS, ENTER 2
 SAVANNA OR SMALL CULTIVATED FIELDS, ENTER 3
 WOODLAND OR FOREST WITH SCATTERED FIELDS, ENTER 4
 SCRUB, ENTER 5
 HEAVY FOREST, ENTER 6
 DENSE JUNGLE, ENTER 7


FOR HELIPORT:  1
 SOIL CONDITION:
? 1
 CBR:
? 7
 VEGETATION:
? 4
```

STEP 9

The computer will now ask for information pertaining to the work force to be employed in the construction. The entry integers will correspond to engineer construction, airborne division engineer supplemented by engineer light equipment company, combat engineer, and airmobile division engineer. Enter the appropriate integer response, and hit "return".

```
INPUT REGARDING THE CONSTRUCTION FORCE IS NOW
 REQUIRED.  IF THE CONSTRUCTION FORCE IS TO BE OF
 ENGINEER CONSTRUCTION, ENTER 1.  IF IT IS TO BE
 AN AIRBORNE DIVISION ENGINEER SUPPLEMENTED BY
 ENGINEER LIGHT EQUIPMENT COMPANY, ENTER 2.  IF IT
 IS TO BE A COMBAT ENGINEER, ENTER 3.  IF IT IS
 TO BE AN AIRMOBILE DIVISION ENGINEER, ENTER 4.
? 3
```

STEP 10

The computer will print out the constructive effort for the heliports per helicopter type and for the total heliport.

```
*****************************************

 THE HELIPORT TO BE DESIGNED IS IN THE FORWARD AREA

CONSTRUCTIVE EFFORT FOR HELIPORT  1

FOR HELICOPTER TYPE: 1 EFFORT IS: 0.00 BATALLION DAYS.

FOR HELICOPTER TYPE: 2 EFFORT IS: 0.00 BATALLION DAYS.

FOR HELICOPTER TYPE: 3 EFFORT IS: 0.00 BATALLION DAYS.

FOR HELICOPTER TYPE: 4 EFFORT IS: 0.00 BATALLION DAYS.
 TOTAL CONSTRUCTIVE EFFORT FOR THE HELIPORT IS:

***** 0.00 *****
```

STEP 11

The computer will now ask what configuration you desire for the heliport. The responses will correspond to runway/taxiway system, pads/hoverlane system, or simply pads. Respond with the correct integer response, and hit the "return".

```
DOES YOUR HELIPORT INCLUDE A RUNWAY/TAXIWAY SYSTEM,
PADS/HOVERLANE SYSTEM, OR SIMPLY PADS?
IF RUNWAY/TAXIWAY,ENTER 1 ... IF PADS ENTER 0 ...
IF TAXI/HOVERLANE, ENTER 2.
? 0
```

STEP 12

The computer will now print the specifications for the heliport in accordance with the type helicopters to be served. Specifications presented can be utilized in making templates as shown in figures 1 through 3 (10).

```
 *** SPECIFICATIONSFOR A FORWARD AREA HELIPORT ***
 ------------ TYPE 1 ------------
 LANDING PAD SPECIFICATIONS ARE:

LENGTH:  0.
WIDTH:  0.
PAD GRADE (DIR OF APP/DEP): .0
MAX CLEAR AREA GRADE: 0.

 LANDING AREA DIMENSIONS ARE:

LENGTH: 72
WIDTH: 72

 NUMBER OF TYPE 1 PADS IS: 6.
 *** SPECIFICATIONSFOR A FORWARD AREA HELIPORT ***
 ------------ TYPE 3 ------------
 LANDING PAD SPECIFICATIONS ARE:

LENGTH:  0.
WIDTH:  0.
PAD GRADE (DIR OF APP/DEP): .0
MAX CLEAR AREA GRADE: 0.

 LANDING AREA DIMENSIONS ARE:
```

LENGTH: **
WIDTH: **

NUMBER OF TYPE 3 PADS IS: 8.
*** SPECIFICATIONSFOR A FORWARD AREA HELIPORT ***
------------ TYPE 4 ------------
LANDING PAD SPECIFICATIONS ARE:

LENGTH: 0.
WIDTH: 0.
PAD GRADE (DIR OF APP/DEP): .0
MAX CLEAR AREA GRADE: 0.

LANDING AREA DIMENSIONS ARE:

LENGTH: **
WIDTH: **

NUMBER OF TYPE 4 PADS IS: 8.
SHOULDERS ARE NOT OF CONCERN FOR FORWARD AREA HELIPORTS.

APPROACH/DEPARTURE ZONE SURFACE RATIO IS 10:1

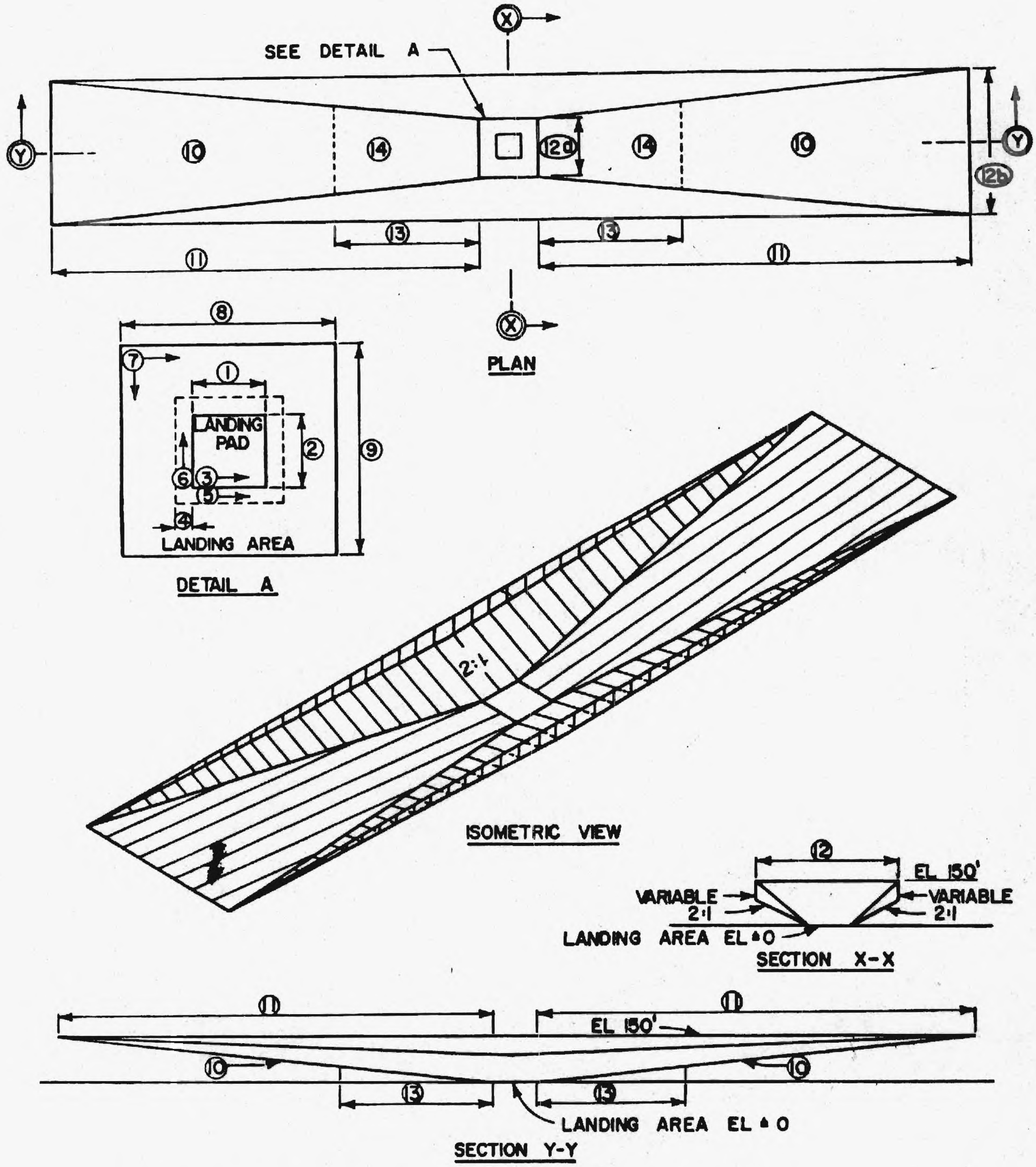
APPROACH/DEPARTURE ZONE LENGTH IS 1500 FEET.
APPROACH/DEPARTURE ZONE WIDTH, OUTER EDGE, IS 500 FEET.

ZONE WIDTH AT EDGE OF LANDING AREA IS EQUAL TO SPECIFIED LANDING AREA WIDTH.

TAKEOFF SAFETY ZONE LENGTH IS 500 FEET....
WIDTH IS SAME AS APPROACH/DEPARTURE ZONE.

THIS COMPLETES HELIPORT SPECIFICATIONS.

PAD AREA TO BE SURFACED IS: 0.
SQUARE FEET.



Figur: 1. Geometric Layout of Helipads (10).

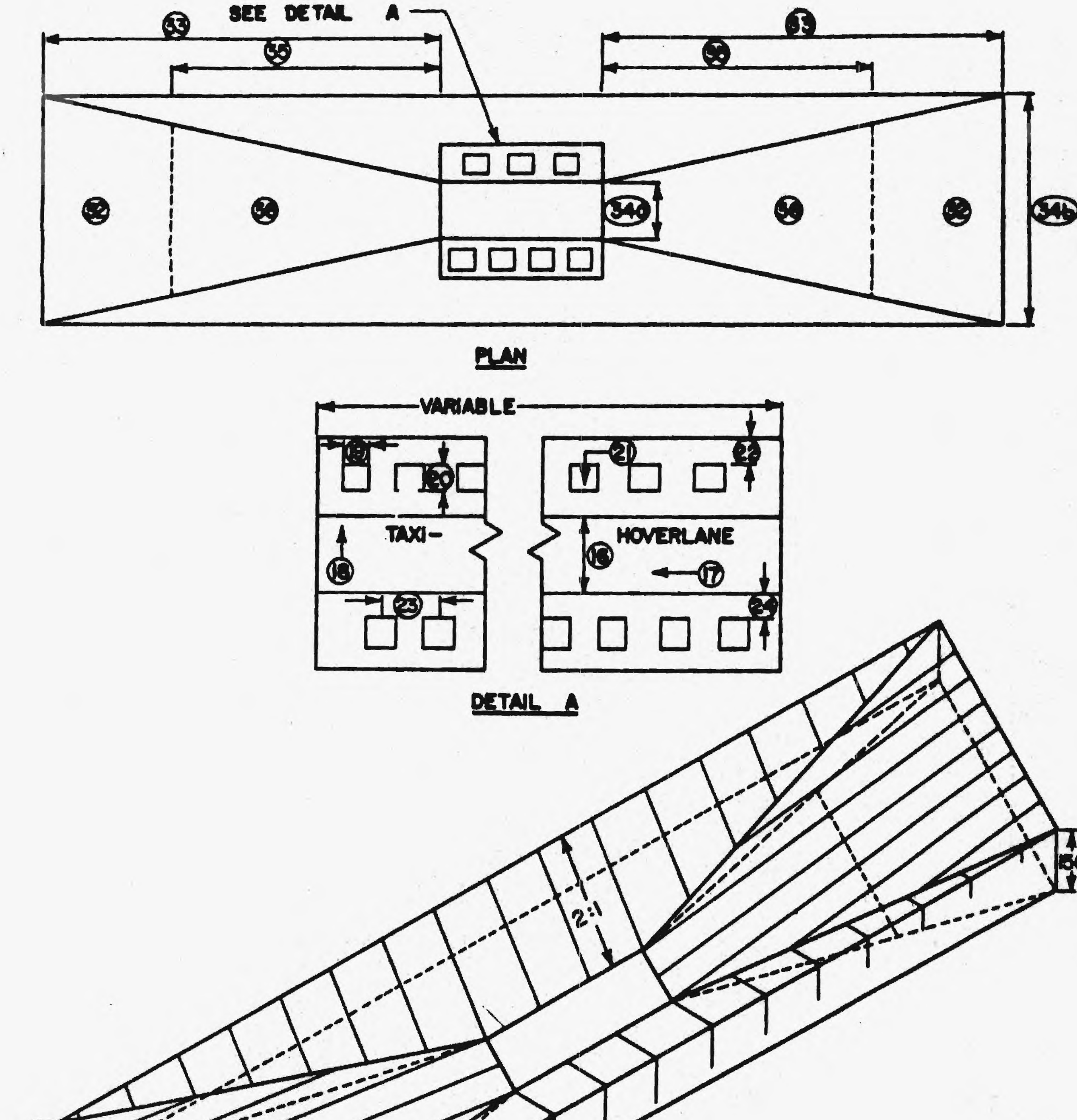


Figure 2. Geometric requirements for heliports with taxi-hoverlanes (10).

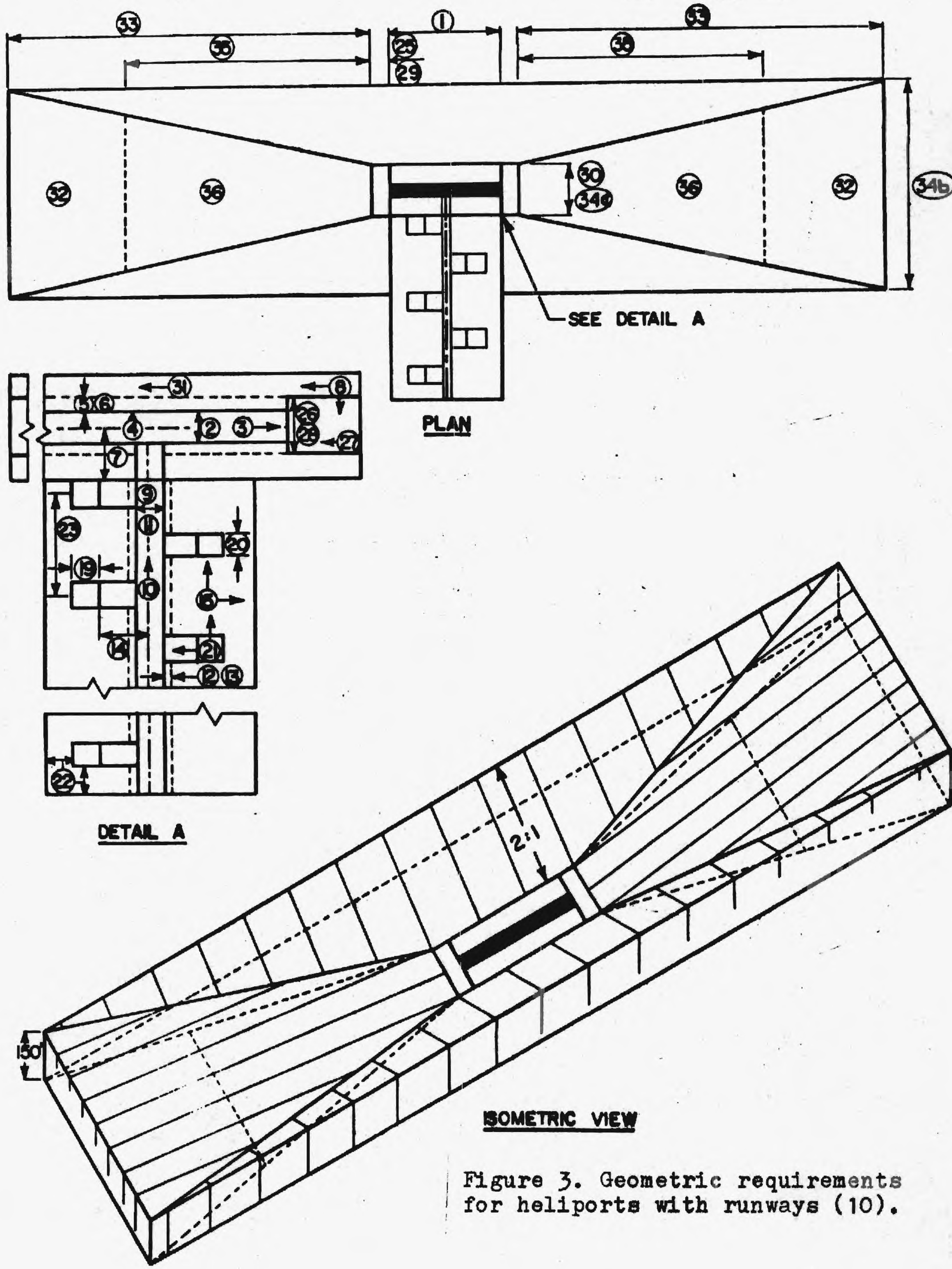


Figure 3. Geometric requirements for heliports with runways (10).

STEP 13

The computer will ask the user about designing the pavement for a particular site. Enter "yes" or "no". If the reply is "no", the program will terminate.

DO YOU WANT TO DESIGN THE PAVEMENT ?

? "YES"

STEP 14

The computer will ask if the site is one which has been evaluated. If so, enter the integer number of the site, just as it was entered in step 7. If this is a new site enter Ø. If the user did not enter a zero, go to step 16.

IF THIS IS A DESIGN FOR A SITE JUST EVALUATED, ENTER THE SITE NUMBER BELOW. IF THIS IS A NEW SITE, ENTER Ø.

? 6

STEP 15

The computer will ask for the CBR of the subgrade at this site.

WHAT IS CBR OF SUBGRADE?

? 5

STEP 16

The computer now asks for the airfield index of the subgrade. Enter the nearest whole number for the site.

```
WHAT IS AIRFIELD INDEX OF EXISTING SUBGRADE?
? 8
```

STEP 17

The computer will provide a selection of surfaces for the design. The user is asked to select one and type the number of the selection into the terminal and hit the "return". If asphaltic concrete is desired, go to step 22.

For matting:

```
SELECT SURFACING REQUIREMENTS.  TABLE 15-1
IN TM5-330 PROVIDES GUIDENCE ON MATTING
SELECTION.  ENTER THE APPROPRIATE CODE FOR
SURFACE DESIRED.
           0     NO MAT, MEMBRANE ONLY
           1     MX18B MATTING
           2     MX19  MATTING
           3     AM2   MATTING
           4     ASPHALT CONCRETE
? 3
```

For asphalt:

```
SELECT SURFACING REQUIREMENTS.  TABLE 15-1
IN TM5-330 PROVIDES GUIDENCE ON MATTING
SELECTION.  ENTER THE APPROPRIATE CODE FOR
SURFACE DESIRED.
           0     NO MAT, MEMBRANE ONLY
           1     MX18B MATTING
           2     MX19  MATTING
           3     AM2   MATTING
           4     ASPHALT CONCRETE
? 4
```

STEP 18

The computer will now ask for the minimum airfield index required from tables D20-D23 (enclosures 1-4 in this user's manual) of TM5-330. Use the table for the heaviest helo and enter the table with the maximum number of take-offs and landings projected. Accuracy need only go to one decimal point, if desired. Type the index number into the terminal and hit the "return".

```
FROM FIGUIRES D-20 TO D-23 IN TM5-330, DETERMINE THE
MINIMUM AIRFIELD INDEX REQUIRED FOR MATTING
SELECTED. USE THE HEAVIEST HELO TO OPERATE
FROM AREA
? 10
```

STEP 19

The computer will determine if stabilization is required. It will query the user to ascertain whether the soil can be compacted to the minimum airfield index. This information is available from table 13-1 (enclosure 5)in TM5-330. The user simply types "yes" or "no", then, hit the "return".

```
IT HAS BEEN DETERMINED THAT STABILIZATION
IS REQUIRED SINCE THE AIRFIELD INDEX OF THE
SUBGRADE IS LESS THAN THE REQUIRED MINIMUM
AIRFIELD INDEX OF:
                    ***

USING TABLE 13-1 IN TM5-330, CAN THE
SUBGRADE BE COMPACTED TO THE REQUIRED MINIMUM
AIRFIELD INDEX?   ENTER YES OR NO.
? "NO"
```

STEP 20

If the answer to step 19 was "no", the computer will display three types of stabilizers with a code for each. Additionally, the user will be directed to table 13-6 (enclosure 6) in TM5-330 to select the depth of treatment and to table 13-7 (enclosure 7) in TM5-330 for information on each available stabilizer. From this table, the user should decide which stabilizer to select, along with the application rate as a percent. For asphalts and emulsions, paragraph 13-11 (enclosure 8) must be consulted to get the value for "R" for the bitumen. The user must know the estimated dry density of the soil to be treated. Now, the user must type in the data as follows: thickness in inches of treatment, stabilizer code, percent of stabilizer to be applied, dry density of the soil in lbs./cu.ft., and "R" (for asphalts only). Separate each number with a comma. "R" can be left out for lime and cement stabilizers. After these values have been typed in, hit the "return".

```
GO TO TABLE 15-3 IN TM5-330 AND SELECT THE
RECOMMENDED DEPTH OF TREATMENT. THEN, USING
TABLE 13-7 IN TM5-330, SELECT ONE OF THE FOLLOWING
STABILIZERS AND SELECT QUANTITY REQUIREMENTS:
        STABILIZER                    CODE
         LIME                          1
         CEMENT                        2
         ASPHALT                       3
FOR ASPHALT CUTBACKS AND EMULSIONS, LOCATE THE
VALUE R IN PARA 13-11 OF TM5-330. NOW ENTER
THE DATA AS FOLLOWS:................
THICKNESS IN INCHES FOR STABILIZATION,
STABILIZER CODE FROM ABOVE, QUANTITY OF
STABILIZER AS PERCENT,ESTIMATED DRY DENSITY
OF SOIL IN LBS/CUFT,R
? 6,2,8,110,0
```

STEP 21

The computer will print the above data back. Then, the user will be asked whether or not the data needs to be reentered. If the data must be reentered because of an error, type "yes" then, hit the "return". The computer will then ask the user to reenter the data. At this time, the user should enter the data as specified in step 6. If the user responded with "no" to the error question, no further data entry is needed for stabilization. In both cases, go to step 27 for the next input action.

```
YOU ENTERED THE FOLLOWING DATA:
THICKNESS IS  6.
STABILIZER TYPE IS  2
PERCENT REQUIRED IS  8.
DRY DENSITY IS  110.
R IS  0.
DO YOU WANT TO CHANGE THIS INPUT?
ENTER YES OR NO.  IF YES, ALL ABOVE INPUT
MUST BE REENTERED.
? "NO"
```

STEP 22

This step is for users who selected asphalt as a pavement surface. If asphalt was not the choice, go to step 27 for the next action. The computer will ask if a frost susceptible design is desired. Type "yes" or "no" into the terminal, then, hit the "return".

```
IS FROST SUSCEPTIBLE DESIGN DESIRED?  ENTER
YES OR NO.
? "YES"
```

STEP 23

The user is asked to enter the CBR of the base material and, if applicable, the CBR of the subbase. The CBR of the base material must be at least 80. If frost susceptible design is desired, the base and subbase material must be non-frost susceptible. Type in the CBR of the base first, then, that of the subbase. Separate both values by a comma. If the criteria for frost susceptible design cannot be met, enter zeroes in both areas. The program will then terminate.

```
BASE AND SUBBASE MTL MUST BE NON-FROST SUSCEPTIBLE
ENTER THE VALUES OF CBR FOR ABOVE MTL'S ONLY IF THEY
MEET THIS CRITERIA.  ENTER THE BASE CBR FOLLOWED
BY SUBBASE CBR(IF APPLICABLE).  IF THIS CRITERIA
CANNOT BE MET, THEN THIS PROGRAM MUST TERMINATE BY
ENTERING ZERO'S.
? 80,30
```

STEP 24

The computer will ask for the plastic index of the subgrade soil. Type in the value, then, hit the "return".

```
WHAT IS THE ESTIMATED PLASTIC INDEX?
OF THE SUBGRADE?
? 18
```

STEP 25

The computer will ask the user to consult table D-37 (enclosure 9) in TM5-330 and select the thickness of the pavement. To use this table, the user enters the graph with the gear weight of the helicopter. Where the weight intersects the CBR line, the vertical scale gives the pavement thickness. Round this number to whole inches and type it into the terminal. Actuate the carriage "return". If there is a subbase material, the above information will be requested again. In this case, use the CBR of the subbase and type it into the terminal, and hit the "return". If frost is not a consideration, go to step 27.

```
FROM TABLE D-37 FOR THE HEAVIEST HELO AND THE
CBR OF THE COMPACTED SUBGRADE.  SELECT THICKNESS
IN WHOLE INCHES OF THE PAVEMENT AND ENTER IT NOW.
? 12


FROM THE TABLE D-37, FOR THE CBR OF THE SUB-
BASE SELECT THICKNESS OF THE PAVEMENT IN WHOLE INCHES
AND ENTER THAT NOW.
? 2
```

STEP 26

Since a frost free design was desired, the computer will direct the user to figure 13-15 (enclosure 10) in TM5-330 to locate the minimum pavement thickness. The user will enter the graph with the load of the heaviest aircraft and intersect the line which describes the subgrade soil. Then, move horizontally to the left in the graph and determine the pavement thickness to the nearest whole inch.

```
SINCE YOU HAVE REQUESTED FROST SUSCEPTIBLE
DESIGN, ENTER PAVEMENT THICKNESS IN WHOLE INCHES
FOR THE SOIL CLASSIFICATION OF THE SUBGRADE FROM
TABLES 13-15 IN TM5-330.  USE WEIGHT OF HEAVIEST
HELO.
? 18
```

STEP 27

The computer will ask if a dust palliative is desired. If the user wants a dust palliative, type "yes"; if not, type "no". In both cases, hit the "return" after typing the appropriate reply. If the answer is "no", go to step 15.

```
DO YOU WANT A DUST PALLIATIVE?
ENTER YES OR NO.
? "YES"
```

STEP 28

The computer will direct the user to table 13-8 (enclosure 11, pages 1&2) in TM5-330. There, the user will select the type of palliative and rate of application. The user shall then type this information under the headings which are underlined. Only type directly under the underlined column. For "NAME", enter only, at the most, 9 characters. Under the appropriate units, enter the quantity of palliative to be applied. A decimal point will count as one space in this area. Enter only one system of units (i.e., only pounds or gallons, but not both).

```
FROM TABLE 13-8 IN TM5-330, SELECT THE APPROPRIATE
STABILIZER AND APPLICATION RATE. ENTER THE
STABILIZER NAME, APPLICATION RATE UNDER PROPER UNITS
*N*A*M*E**          *GAL          *LBS
? RC-70              .5
```

STEP 29

The design will be outputted as sentences.

For matting: YOU SELECTED THE AM2 MATTING SYSTEM FOR AN AREA OF 0.0 SQUARE FEET.

THIS SURFACE REQUIRES 1388 BUNDLES OF MATTING AND 698MANHOURS TO INSTALL.

YOU ARE TO APPLY 8.0 PERCENT CEMENT TO THE SOIL FOR A DEPTH OF TREATMENT OF 6.0 INCHES.

THIS WILL REQUIRE 0.00 POUNDS OF STABILIZER TO TREAT 0.0 CUBIC YARDS OF SOIL.

YOU SELECTED RC-70 AS A DUST PALLIATIVE.
AN AREA OF 2469.14 SQUARE YARDS WILL BE TREATED AT THE RATE OF .50 GALLONS PER SQUARE YARD.

THIS OPERATION WILL REQUIRE 20370.37 GALLONS OF STABILIZER AND REQUIRES 0 MANHOURS TO APPLY.

For asphalt:

YOU SELECTED ASPHALT PAVEMENT FOR AREA OF: 400000.0
SINCE DESIGN IS NON-FROST SUSCEPTIBLE, THE PAVEMENT IS:

ASPHALT THICKNESS 1.5 INCHES
BASE THICKNESS 4.0 INCHES
SUBBASE THICKNESS 8.5 INCHES
FILTER THICKNESS IS 4.0 INCHES

BASE AND SUBASE MUST BE COMPACTED TO 100%. TOP SIX INCHES OF SUBGRADE MUST BE COMPACTED TO 95%. FILTER MATERIAL IS A COARSE GRAINED SAND.

THIS DESIGN REQUIRES 20370.4 CUBIC YDS OF BASE,SUBBASE, AND FILTER MTL AND REQUIRES ********** MANHOURS TO COMPLETE.

YOU SELECTED RC-70 AS A DUST PALLIATIVE.
AN AREA OF 22222.22 SQUARE YARDS WILL BE TREATED AT THE RATE OF .50 GALLONS PER SQUARE YARD.

THIS OPERATION WILL REQUIRE 20370.37 GALLONS OF STABILIZER AND REQUIRES 4 MANHOURS TO APPLY.

STEP 30

After it's complete, the computer will ask if another site is to be designed. Enter "yes" or "no", then, hit the "return". If the answer is "no", the program will terminate. If "yes", go back to step 1 and repeat the process.

```
 DO YOU WANT TO DESIGN ANOTHER SITE?
 ENTER YES OR NO.
? "NO"
     .323 CP SECONDS EXECUTION TIME.
/TED
```

If an input file is to be used with the main program, the file must be in the following format:

LINE ONE: four integers are to be on the first line. The first two define the number of heliports to be compared by the program, the next defines the type of heliport concerned, and the last defines the construction force employed to do the work.

Example: 0413 - 04 indicates that four heliports are to be compared.
1 indicates that it will be a support area heliport.
3 indicates that a combat engineer force will construct the heliport.

LINE TWO: four real numbers are to be on this line, each of which defines a quantity of a particular type helicopter to be served by the heliport.

Example: ␣6.␣0.91.␣0. - ␣6. indicates that six type one helicopters are using the heliport.
␣0. indicates that no type two helicopters are to be served.
91. indicates one company of type three helicopters.
␣0. indicates no type four helicopters.

Note- In every case, all fields of the data line must be full, or accounted for by a space. If three spaces are available, as in line two, the spaces must be accomodated by a blank, digit, or decimal. Whwn real numbers are to be entered, a decimal must be in the string of digits at some point.

LINE THREE: six real numbers are to be entered on this line; they define the terrain characteristics for heliport one of slope, soil thickness, soil type, soil condition, CBR of subgrade, and area vegetation.

Example: ␣2.␣1.␣3.␣1.␣␣5.␣4. -

␣2. indicates a slope of between 2 and ten percent.
␣1. indicates a soil thickness of less than 2 feet.
␣3. indicates a soil type of clay.
␣␣5. indicates a CBR of 5.
␣4. indicates a vegetation of woodland or forest with scattered fields.

All data entries are the same figures as defined earlier in the user's manual, with the exception that when entered in the interactive mode, the preciseness of format and the need for decimal points is foregone by use of a free format. To determine what digit values must be entered to properly define characteristics and information, see steps one through seven of the user's manual.

LINE FOUR: would be the terrain characteristics for heliport two of the compared group. The format would be the same as line three.

LINE FIVE: and so on ... up to line twelve, if ten heliports are compared.

Use of the data file will accelerate the computer operation as much of the interaction is avoided. This is a great benefit if multiples of heliports are compared. The file data serves the subroutines CEFF and LANZON.

The following page provides direction as to the execution commands necessary for use of afile input while working on the CYBER 74 computer.

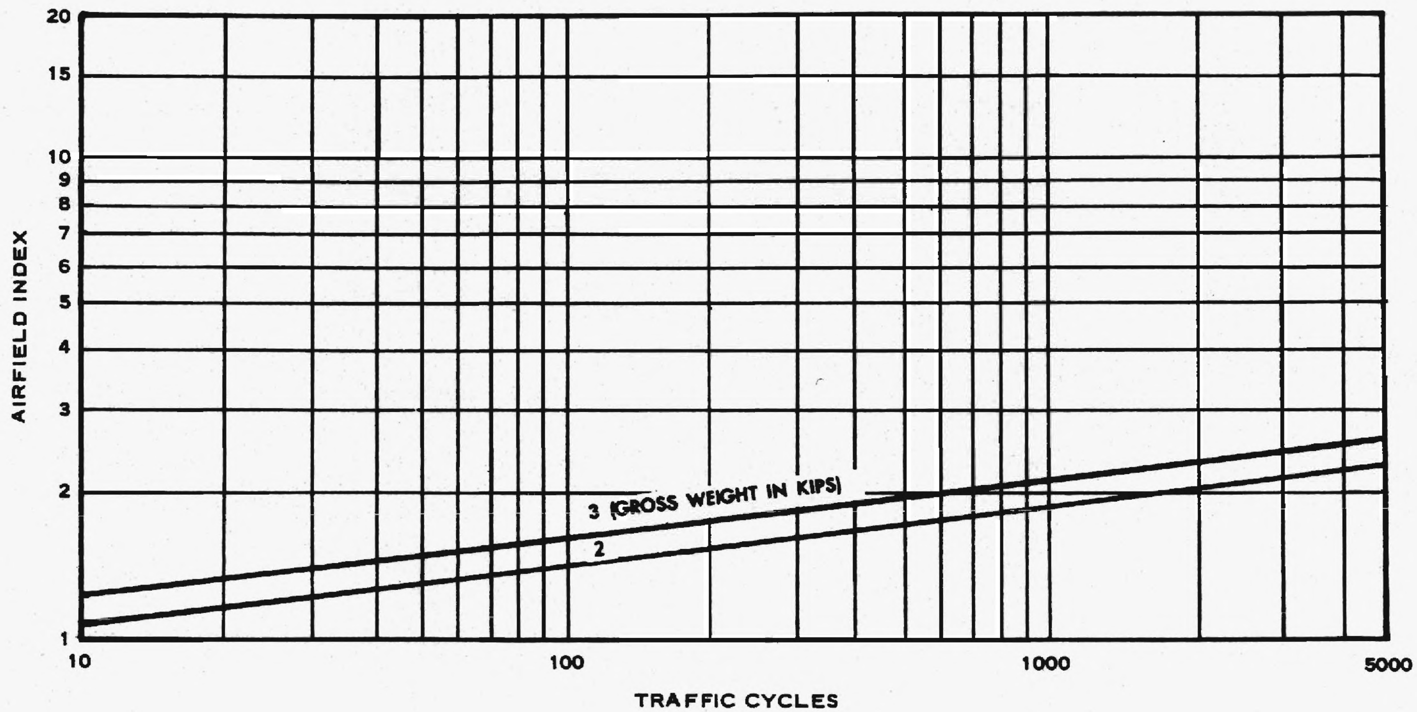
To utilize the data program with the main program:

1) the data file must have a name of seven letters or less.

2) the command to the computer to execute the main program must be preceded by the following:

```
ATTACH,PFL/UN=LIBRARY.
X,LIBRARY,PFL.
```

3) when the computer asks for the file name of your data program, type it in and the majority of the specification data input (CEFF and LANZON subroutines) from the interactive mode will be accomodated.

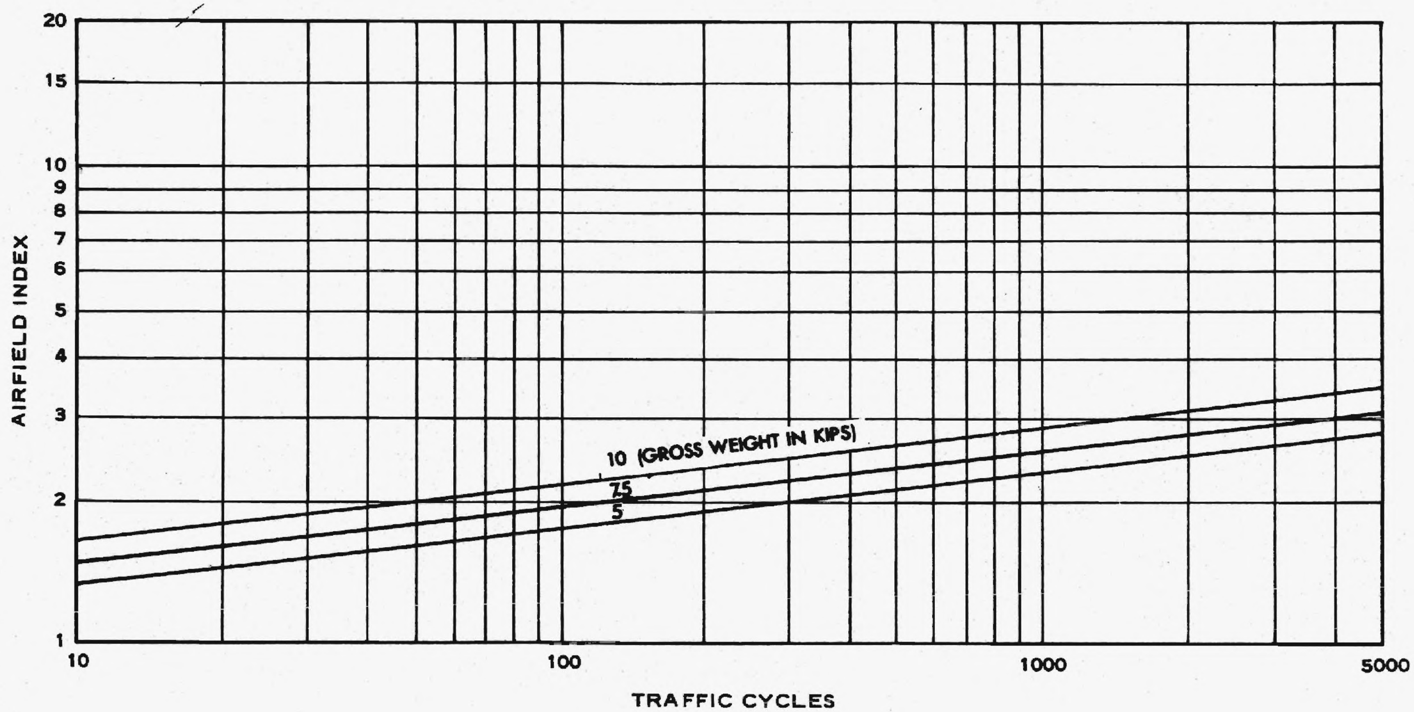


LEGEND

——— UNSURFACED WITH OR WITHOUT MEMBRANE

NOTE: ONE CYCLE IS EQUAL TO ONE TAKE-OFF AND ONE LANDING.

Figure D–20. Subgrade strength requirements, OH–6A helicopter.



LEGEND

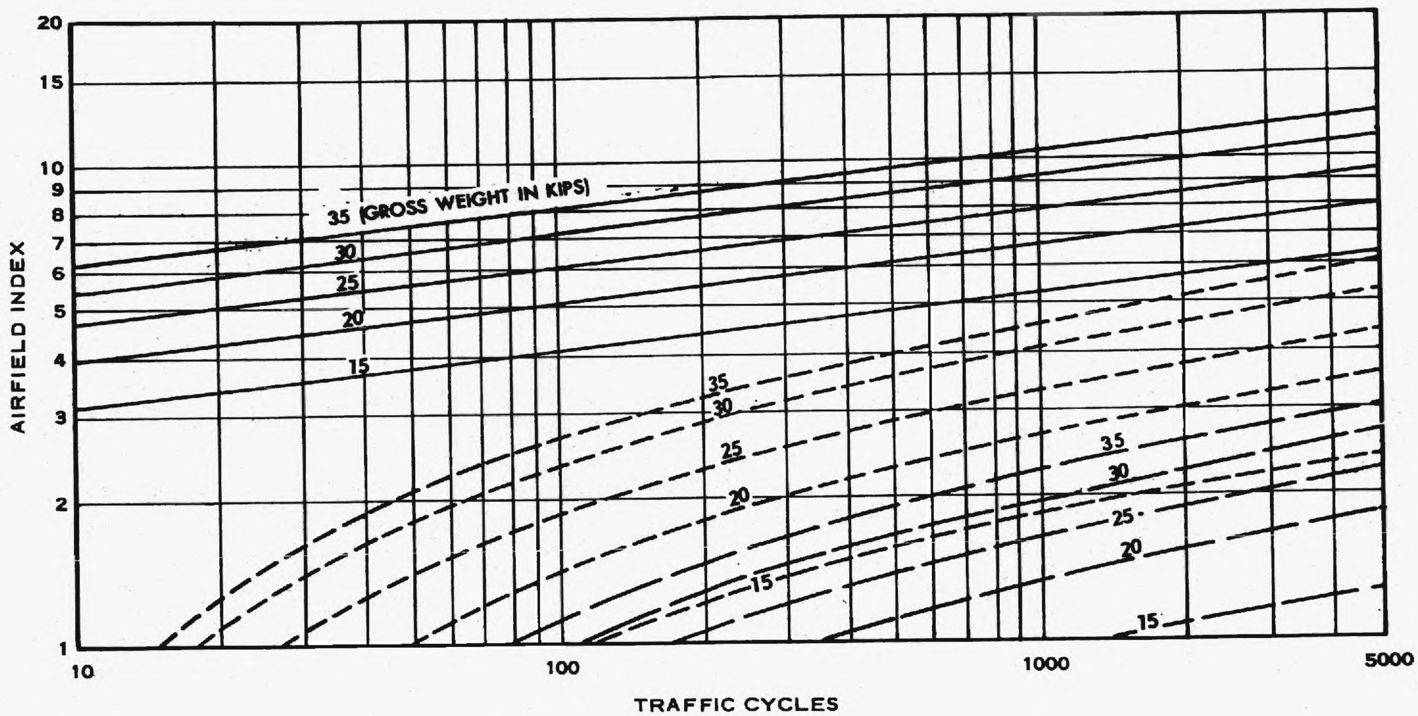
UNSURFACED WITH OR WITHOUT MEMBRANE

NOTE: ONE CYCLE IS EQUAL TO ONE TAKE-OFF AND ONE LANDING.

Figure D–21. Subgrade strength requirements, UH–1D helicopter.

ENCLOSURE 3

123



LEGEND

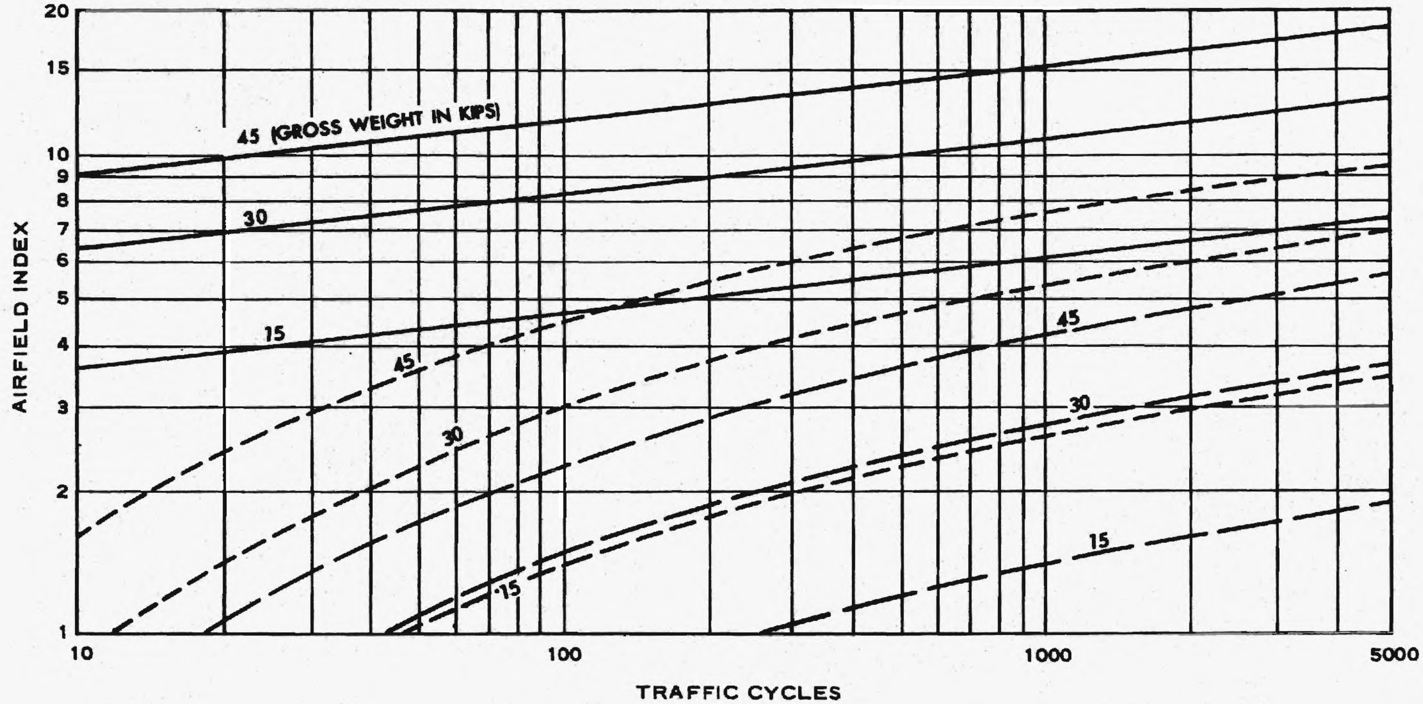
———— UNSURFACED WITH OR WITHOUT MEMBRANE

– – – – LIGHT DUTY MAT

—— —— MEDIUM DUTY MAT

NOTE: ONE CYCLE IS EQUAL TO ONE TAKE-OFF AND ONE LANDING.

Figure D-22. Subgrade strength requirements, CH-47 helicopter.



LEGEND

———— UNSURFACED WITH OR WITHOUT MEMBRANE

– – – – LIGHT DUTY MAT

—— —— MEDIUM DUTY MAT

NOTE: ONE CYCLE IS EQUAL TO ONE TAKE-OFF AND ONE LANDING.

Figure D-23. Subgrade strength requirements, CH-54 helicopter.

ENCLOSURE 4

Table 18-1. Characteristics of Soils Pertinent to Battle, Forward, Support, and Rear Area Airfields and Heliports

Major Divisions (1)	(2)	Symbol: Letter (3)	Symbol: Hatching (4)	Symbol: Color (5)	Name (6)	Value as a Subgrade Beneath Landing Mat or as an Unsurfaced Area: Dry (7)	Value as a Subgrade Beneath Landing Mat or as an Unsurfaced Area: Wet (8)	Freedom of Dry Surfaces from Dust: Firm Surface (9)	Freedom of Dry Surfaces from Dust: Loose Surface (10)	Drainage Characteristics (11)	Compaction Equipment (12)	Unit Dry Weight lb per cu ft (13)	Airfield Index (14)
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Red	Well-graded gravels or gravel-sand mixtures, little or no fines	Excellent	Excellent	Excellent to good	Excellent to good	Excellent	Crawler-type tractor, rubber-tired roller, steel-wheeled roller, vibratory compactors.	125-140	NA
		GP		Red	Poorly graded gravels or gravel-sand mixtures, little or no fines	Very good	Excellent	Excellent to good	Excellent to good	Excellent	Crawler-type tractor, rubber-tired roller, steel-wheeled roller, vibratory compactors.	110-140	NA
		GM d		Yellow	Silty gravels, gravel-sand-silt mixtures	Excellent	Very good	Good	Good to fair	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	125-145	NA
		GM u		Yellow	Silty gravels, gravel-sand-silt mixtures	Excellent	Good	Good	Good to fair	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	115-135	NA
		GC		Yellow	Clayey gravels, gravel-sand-clay mixtures	Excellent	Good	Good	Good to fair	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	130-145	NA
	SAND AND SANDY SOILS	SW		Red	Well-graded sands or gravelly sands, little or no fines	Very good	Very good	Good	Good to fair	Excellent	Crawler-type tractor, rubber-tired roller, vibratory compactors.	110-130	NA
		SP		Red	Poorly graded sands or gravelly sands, little or no fines	Good	Very good	Good	Fair	Excellent	Crawler-type tractor, rubber-tired roller, vibratory compactors.	105-135	10-15
		SM d		Yellow	Silty sands, sand-silt mixtures	Very good	Good	Fair	Fair to poor	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	120-135	13-15
		SM u		Yellow	Silty sands, sand-silt mixtures	Very good	Fair	Fair	Fair to poor	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-130	10-15
		SC		Yellow	Clayey sands, sand-clay mixtures	Very good	Fair	Fair	Fair to poor	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-135	7-15
FINE-GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Good	Very poor	Fair to poor	Poor	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	90-130	13 or less
		CL		Green	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Good	Poor	Fair to poor	Poor	Practically impervious	Rubber-tired roller, sheepsfoot roller	90-130	13 or less
		OL		Green	Organic silts and organic silt-clays of low plasticity	Good	Very poor	Fair to poor	Poor	Poor	Rubber-tired roller, sheepsfoot roller	90-105	7 or less
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Good	Very poor	Good to fair	Poor	Fair to poor	Sheepsfoot roller, rubber-tired roller	80-105	10 or less
		CH		Blue	Inorganic clays of high plasticity, fat clays	Good	Poor	Good to fair	Poor	Practically impervious	Sheepsfoot roller, rubber-tired roller	90-115	13 or less
		OH		Blue	Organic clays of medium to high plasticity, organic silts	Good	Very poor	Good to fair	Poor	Practically impervious	Sheepsfoot roller, rubber-tired roller	80-110	7 or less
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils	Very poor	Extremely poor	Good	Poor	Fair to poor	Compaction not practical	--	--

Note:

1. Column 3, division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is on basis of Atterberg limits; suffix d (e.g., GMd) will be used when the liquid limit is 25 or less and the plasticity index is 5 or less; the suffix u will be used otherwise.
2. In the first 7 items of columns 7 and 8, where gravel, gravelly soils, sands, or sandy soils are used in an unsurfaced area, they should be stabilized to prevent aircraft damage from loose particles. Landing mat will not usually be required on these soils. Where landing mat is used which does not have a flat bottom surface, a cushion layer of fine sand or some other similar fine-grained material will be required for seating of the mat.
3. In column 12, the equipment listed will usually produce the required densities with a reasonable number of passes when moisture conditions and thickness of lift are properly controlled. In some instances, several types of equipment are listed because variable soil characteristics within a given soil group may require different equipment. In some instances, a combination of two types may be necessary.
   a. Unsurfaced areas. Steel-wheeled and rubber-tired rollers are recommended for hard, angular materials with limited fines or screenings. Rubber-tired equipment is recommended for softer materials.
   b. Areas to be surfaced with landing mat. Rubber-tired equipment is recommended for rolling during final shaping operations for most soils and processed materials.
   c. Equipment size. The following sizes of equipment are necessary to assure the high densities required for airfield construction:
      Crawler-type tractor -- total weight in excess of 30,000 lb.
      Rubber-tired equipment -- wheel load in excess of 15,000 lb, wheel loads as high as 40,000 lb may be necessary to obtain the required densities for some materials (based on contact pressure of approximately 65 to 150 psi).
      Sheepsfoot roller -- unit pressure (on 6- to 12-sq-in. foot) to be in excess of 250 psi and unit pressures as high as 650 psi may be necessary to obtain the required densities for some materials. The area of the foot should be at least 5 percent of the total peripheral area of the drum, using the diameter measured to the faces of the feet.
4. Column 13, unit dry weights are for compacted soil at optimum moisture content for CE 55 (modified AASHO) compaction effort.
5. Column 14, NA indicates that the airfield index is greater than 15. This is the maximum value which can be measured by the airfield cone penetrometer.
6. Columns 9 and 10, wet or damp soils are essentially free from dust.

Table 13-6. Design Requirements for Strength Improvement Function of Soil Stabilization

Pertinent Airfield Type	Traffic Areas: Minimum Stabilization Strength Required.[1]	Traffic Areas: Thickness of Soil Stabilization Required (in.) for Subgrade Airfield Index of 5-6	6-8	8-10	10-12	12-15	>15	Nontraffic Areas: Minimum Stabilization Strength Required[1]	Nontraffic Areas: Thickness of Soil Stabilization Required (in.) for Subgrade Airfield Index of 5-6	6-8	8-10	10-12	12-15	>15
Battle area:														
Medium lift:														
a. No mat	6	11												
Forward area:														
Surveillance:														
a. No mat	8	8	7											
Medium lift:														
a. No mat	8	15	12											
Support area:														
Medium lift:														
a. No mat	10	22	18	12				6	10					
b. With LM	8	10	6											
Heavy lift:														
a. No mat	15	40	29	19	14	10		9	10	9	7			
b. With LM	10	28	18	8										
c. With MM	6	18												
Tactical:														
a. No mat								11	7	6	5	5		
b. With LM	10	8	6	5										
Rear area:														
Army:														
a. No mat	10	12	10	8										
Medium lift:														
a. No mat	15	30	26	18	14	10		8	12	10				
b. With LM	10	18	14	6										
c. With MM	6	8												
Heavy lift:														
a. No mat								12	14	12	10	9		
b. With LM	12	42	33	16	5			6	5					
c. With MM	8	33	22											
Tactical:														
a. No mat								13	10	8	6	5		
b. With LM	12	12	9	5	5									
c. With MM	8	7	5											

Note: Practical limitations generally will preclude the consideration of chemical stabilization methods to develop an improved quality layer in excess of 16 inches thick.

1 Airfield index.

ENCLOSURE 6

Table 13-7. Summary of Soil Stabilizers for Strength Improvement Function

(1) Material	(2) Form of Material	(3) Applicable Soil Range	(4) Estimated Range of Quantity Requirements (%)†	(5) Minimum Curing Time Requirements
Portland cement	Powder	Gravels	3-4	24 hours
		Sands	3-5	
		Silts-clayey silts	4-6	
		Clays	6-8	
Lime				
1. Hydrated	Powder	Clayey gravels	2-4	7 days
		Silty clays	5-10	
		Clays	3-8	
2. Quicklime	Powder	Clayey gravels	2-3	4 hours
		Silty clays	3-8	
		Clays	3-6	
Bituminous material				
1. Asphaltic cutbacks				
a. RC-70 to RC-800	Liquid	Sands	5-7††	1-3 days
		Silty sands	6-10	
		Clayey sands	6-10	
b. MC-70 to MC-800	Liquid	Sands	5-7	3-5 days
		Silty sands	6-10	
		Clayey sands	6-10	
2. Asphaltic emulsions	Liquid	Sands	5-7	1-3 days
		Silty sands	6-10	
		Clayey sands	6-10	

† Based on dry density of existing soil.

†† All quantities listed for asphalts are actual bitumen requirements, exclusive of volatiles.

Paragraph 13-11

The quantity R in the formula for asphalts varies with the particular asphalt type and grade. The following values may be u... estimate of R:

Type and grade	*R*	*Type and gra...*
MC–70	50	RC–250
MC–250	60	RC–800
MC–800	70	SS–1 or SS–K
RC–70	55	

TIRE INFLATION 100 PSI

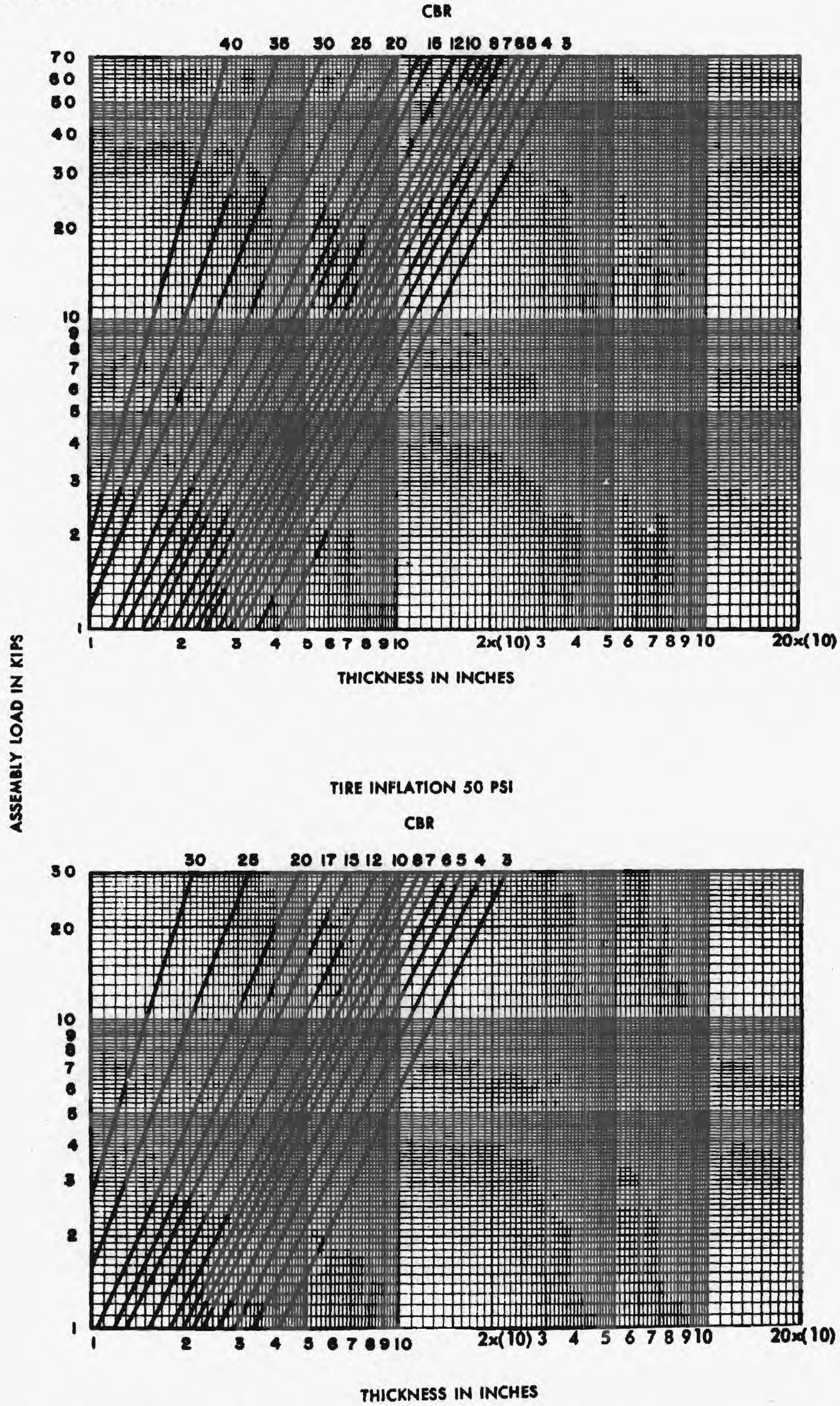
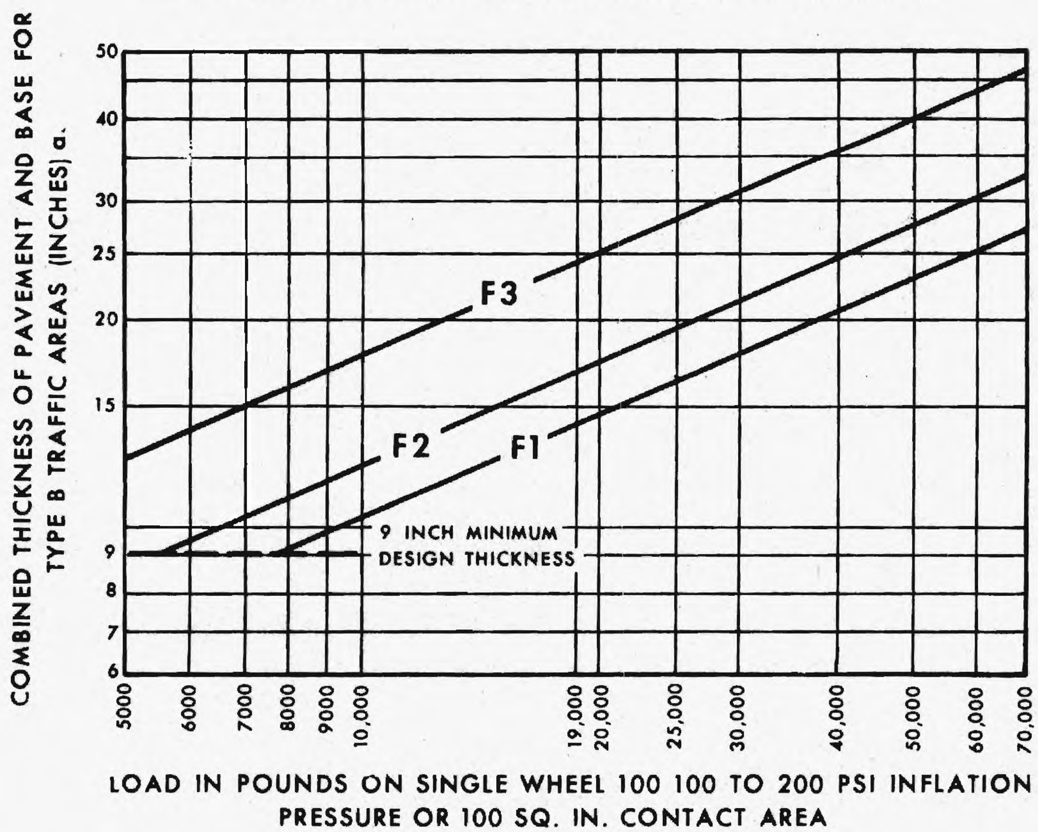


Figure D-37. Flexible pavement evaluation curves, army airfields and heliports, single wheel, full operational category.

GROUP	DESCRIPTION
F1	GRAVELLY SOILS CONTAINING BETWEEN 3 AND 10 PERCENT FINER THAN 0.02mm BY WEIGHT
F2	(a) GRAVELLY SOILS CONTAINING BETWEEN 10 AND 20 PERCENT FINER THAN 0.02mm BY WEIGHT (b) SANDS CONTAINING BETWEEN 3 AND 15 PERCENT FINER THAN 0.02mm BY WEIGHT
F3	(a) GRAVELLY SOILS CONTAINING MORE THAN 20 PERCENT FINER THAN 0.02mm BY WEIGHT (b) SANDS, EXCEPT VERY FINE SILTY SANDS, CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF MORE THAN 12
F4	(a) ALL SILTS (b) VERY FINE SILTY SANDS CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF LESS THAN 12 (d) VARIED CLAYS AND OTHER FINE-GRAINED BANDED SEDIMENTS

NOTE: FOR DESIGN OVER F4 SUBGRADE SOILS SEE PARAGRAPH 13-28



a THE THICKNESS WILL BE REDUCED 10 PERCENT FOR TYPE C TRAFFIC AREAS.

Figure 13–15. Frost condition reduced subgrade strength design curves for flexible pavements. Load in pounds on single wheel 100 to 200 psi inflation pressure on 100 sq in contact area.

Table 13-8. Summary of Soil Stabilizing Materials for Function of Dust Control and/or Soil Waterproofing.

(1) Material	(2) Form of Material	(3) Acceptable Application Methods (s)	(4) Applicable Soil Range	Primary Function, Area of Application, and Degree of Effectiveness[a]: Dust Palliative (5) Traffic	Dust Palliative (6) Nontraffic or Limited Traffic	(7) Waterproofer (Traffic or Limited Traffic Areas Only)	Quantity Requirements[b] (8) gal per sq yd	Quantity Requirements[b] (9) lb per sq yd	(10) Minimum Curing Time Requirements	(11) Remarks
Group I: Bituminous Materials										
Outback Asphalts										
a. RC-70 to RC-250	Liquid	Admix	Gravel to sand	M	V	M	0.18-0.25	1.5-2.0	12-24 hr	All cutback asphalts will require preheating for penetration or admix application
		Penetration	Gravel to silty sand	M	V	X	0.25-0.50	2.1-4.0	12-24 hr	
b. MC-70 to MC-250	Liquid	Admix	Sand to silt	M	V	M	0.25-0.55	2.0-4.5	>24 hr	
c. MC-30 to MC-250	Liquid	Penetration	Gravel to silty sand	M	V	X	0.25-0.50	2.1-4.0	>24 hr	
d. SC-70 to SC-250	Liquid	Admix	Sand to clay of moderate plasticity	M	V	M	0.55-0.72	4.5-6.0	>24 hr	
		Penetration	Gravel to silty sand	M	V	X	0.25-0.50	2.1-4.0	>24 hr	
Road Tars										
a. RT-3 to RT-6	Liquid	Admix	Gravel to clay of moderate plasticity	V	V	V	0.30-0.50	2.5-4.0	Several days	Same comments as above for cutbacks
b. RT-1 to RT-6	Liquid	Penetration	Gravel to silty sand	X	X	X	0.25-0.50	2.1-4.0	Several days	
Emulsified Asphalts										
a. SS-1 or SS-1h (Anionic)	Liquid	Admix	Gravel to silty sand	X	X	X	0.10-0.50 (diluted)	0.8-4.0	Several hr	Requires water for dilution and requires careful control for proper emulsion break. Dilutions up to 5:1 by water are used
		Penetration	Gravel to silty sand	X	X	X	0.10-0.50	0.8-4.0	Several hr	
Special Asphalts										
a. Peneprime[c]	Liquid	Penetration	Gravel to clay of moderate plasticity	M	V	M	0.25-0.5	2.1-4.0	4-8 hr	Excellent penetration ability; requires heating for spraying
Group II: Cementing Material										
Portland Cement	Powder	Admix	All	S	S	S	--	1.5-4.0	12-24 hr	Normally used for strength, but will also provide modest benefits for dust control and waterproofing when used in low quantities as a soil modifier
Lime (Hydrated)	Powder	Admix	Clays of moderate to high plasticity	S	S	S	--	1.5-4.0	12-24 hr	(Same as comment above)
Group III: Resinous Systems										
Lignin	Liquid or powder	Admix	Sand to clay of low plasticity	S	S	S	--	4.0-8.0	12-24 hr	Benefits may be only temporary since resin is water soluble
		Penetration	Sand to silty sand	X	X	X	0.50-1.0	4.0-8.0	2-6 hr	
Concrete Curing Compound (with paraffin base resin)	Liquid	Penetration	Silts to clays	S	M	X	0.1-0.2	1.0-2.0	2 hr	Fairly viscous; requires special spray nozzles, forms thin, moderately flexible film on surface when cured; curing depends on temperature and humidity

a Relative degree of effectiveness is indicated as follows: S = slightly, M = moderately, V = very, X = Applicable, but effectiveness unknown, Blank = not applicable.
b For all admixture treatments, the quantities indicated are for a 1-in. depth of treatment and assume a compacted dry density of 100 lb per cu ft.
c Proprietary material.

ENCLOSURE 11 - Page 1

Table 13-8. Summary of Soil Stabilizing Materials for Function of Dust Control and/or Soil Waterproofing—Continued

				Primary Function, Area of Application, and Degree of Effectiveness			Quantity Requirements			
				Dust Palliative						
(1) Material	(2) Form of Material	(3) Acceptable Application Methods (s)	(4) Applicable Soil Range	(5) Traffic	(6) Nontraffic or Limited Traffic	(7) Waterproofer (Traffic or Limited Traffic Areas Only	(8) gal per sq yd	(9) lb per sq yd	(10) Minimum Curing Time Requirements	(11) Remarks
				Group IV: Salts						
Sodium Chloride	Granules	Admix	Gravel to silt (with fines present)	S	S	--	--	0.4-0.8	0	All salts are corrosive to metal; subject to leaching; rely on absorption of moisture from air to palliate dust. Brine solution forms surface crust
Calcium Chloride	Powder or flakes	Admix	Gravel to silt (with fines present)	S	S	--	--	0.4-0.8	0	
Brine Solution	Liquid	Penetration	Sand to clay of low plasticity	S	S	--	0.5-1.5 (80% solution)		0	
				Group V: Miscellaneous Materials						
Water	Liquid	Penetration	All	S	S	--	(As needed)		0	Temporary measure only
Various Oils	Liquid	Penetration	All	S	X	--	0.5-1.0		0	Temporary measure only; may require frequent application

APPENDIX E

PROGRAM LISTING - HELICOPTER LANDING SITE PROGRAM

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345

      PROGRAM HPORT(INPUT,OUTPUT,TAPE1,TAPE5=INPUT,TAPE6=
     + OUTPUT)
      DIMENSION IVOL(4),SLOP(10),SOTY(10),SOCO(10),CLRIN(6,4),DIFDR
     + (4,4),GRADIF(5,2),ROVOL(3,4),GRAFAC(10),HDES(4)
      DIMENSION VEGE(10),THIC(10),CBR(10),HDES2(4)
      DIMENSION NUMCOM(4),BATA(4)
      INTEGER TYPE,C
      DATA IVOL/1,2,4,6/
      DATA CLRIN/0.0,0.1,0.5,2.0,5.0,6.0,0.0,0.11,0.55,2.20,5.50,
     + 6.60,0.0,0.12,0.6,2.4,6.0,7.2,0.0,0.13,0.65,2.6,6.5,7.8/
      DATA DIFDR/0.3,0.5,1.0,0.7,0.3,0.1,0.7,0.8,0.5,0.1,0.0,0.5,
     + 0.7,0.4,0.0,0.0,0.4,0.6,0.4,0.0/
      DATA GRADIF/0.1,0.1,0.2,0.2,1.5,0.1,0.2,0.3,0.3,1.5/
      DATA ROVOL/20,10,0,40,20,10,60,50,30,90,80,60/
      DATA BATA/0.75,1.25,1.50,2.60/
      WRITE(6,100)
100   FORMAT(//,"DO YOU HAVE A FILE INPUT?")
      READ(5,105)ANS
105   FORMAT(A3)
      AYES="YES"
      NNO="NO"
      IF(ANS.EQ.AYES) GO TO 216
      WRITE(6,110)
110   FORMAT(//,"AS YOU DO NOT HAVE A FILE, YOU WILL BE")
      PRINT *,"PROVIDING DATA REGARDING YOUR HELIPORT THROUGH"
      PRINT *,"ANSWERING QUESTIONS.  VARIOUS QUESTIONS WILL BE"
      PRINT *,"ASKED- ANSWER THEM IN THE MANNER PRESCRIBED AND"
      PRINT *,"AS ACCURATELY AS POSSIBLE."
      WRITE(6,111)
111   FORMAT(//,"WHAT TYPE HELIPORT IS TO BE DESIGNED, FORWARD")
      PRINT *,"AREA OR SUPPORT AREA ?"
      PRINT*,"IF FORWARD, ENTER 0 ... IF SUPPORT, ENTER 1."
      READ *,TYPE
      WRITE(6,115)
115   FORMAT(//,"YOU ARE NOW READY TO ENTER DATA PERTAINING")
      PRINT *,"TO HELICOPTER TYPES AND QUANTITIES.  TYPE ONE (1)"
      PRINT *,"HELICOPTERS ARE THE OH-6, OH-13, AND/OR OH-23."
      PRINT *,"ENTER THE TOTAL NUMBER OF TYPE ONE HELICOPTERS ARE"
      PRINT *,"EXPECTED TO USE THE HELIPORT."
      PRINT *,"***NOTE***  IF THERE IS TO BE A COMPANY OF HELICOPTERS,"
      PRINT *,"ENTER 91, - TWO COMPANIES, 92, - THREE COMPANIES,93 -"
      PRINT *,"AND SO ON.  IF LESS THAN ONE COMPANY, ENTER THE"
      PRINT *,"SPECIFIC NUMBER."
      READ *,HDES(1)
      WRITE(6,120)
120   FORMAT(/,"TYPE TWO (2) HELICOPTERS INCLUDE THE UH-1,")
      PRINT *,"AH-1, AH-56, AND/OR OH-58.  ENTER THE NUMBER OF"
      PRINT *,"TYPE TWO HELICOPTERS IN THE SAME MANNER AS ABOVE."
      READ *,HDES(2)
      WRITE(6,125)
125   FORMAT(/,"TYPE THREE (3) HELICOPTERS INCLUDE THE UH-19,")
      PRINT *,"CH-34, CH-46, AND/OR CH-47.  ENTER THE NUMBER OF"
      PRINT *,"TYPE THREE HELICOPTERS IN THE SAME MANNER."
      READ *,HDES(3)
      WRITE(6,130)
130   FORMAT(/,"TYPE FOUR (4) HELICOPTERS INCLUDE THE CH-25,")
      PRINT *,"CH-37, CH-53, AND/OR CH-54.  ENTER THE NUMBER"
      PRINT *,"OF TYPE FOUR HELICOPTERS IN THE SAME MANNER."
      READ *,HDES(4)
133   DO 140 I=1,4
      IF(HDES(I).LT.90)GO TO 135
      NUMCOM(I)=HDES(I)-90
```

```
      IF(I.EQ.2) HDES2(I)=NUMCOM(I)*25
      IF(I.EQ.3) HDES2(I)=NUMCOM(I)*16
      IF(I.EQ.4) HDES2(I)=NUMCOM(I)*8
      GO TO 140
 135   NUMCOM(I)=0
      HDES2(I)=HDES(I)
 140   CONTINUE
      WRITE(6,145)
 145   FORMAT(//,"AS A CHECK ON YOUR HELICOPTER DATA INPUT, YOUR")
      PRINT *,"DATA WILL BE TABULATED AND PRINTED.  CHECK AND CONFIRM"
      PRINT *,"THESE VALUES."
      WRITE(6,150)
 150   FORMAT(/,"HELICOPTER TYPE",8X,"NO. OF INDIVIDUAL HELICOPTERS"
     + ,8X,"NO. OF COMPANIES")
      DO 160 I=1,4
      WRITE(6,155)I,HDES2(I),NUMCOM(I)
 155   FORMAT(/,6X,I1,31X,F4.0,29X,I2)
 160   CONTINUE
      WRITE(6,162)
 162   FORMAT(//,"IS THE PRINTED DATA EQUIVALENT TO THE DATA")
      PRINT *,"YOU INPUT?"
      READ(5,165)ANDACO
 165   FORMAT(A3)
      AYES2="YES"
      NNO2="NO"
      IF(ANDACO.EQ.AYES2)GO TO 190
      WRITE(6,170)
 170   FORMAT(/,"HOW MANY ERRORS ARE THERE?")
      READ *,LGOOF
      DO 185 I=1,LGOOF
      WRITE(6,175)I
 175   FORMAT(/,"ERROR ",I1," OCCURS ON WHICH HELICOPTER
     + TYPE?")
      READ *,Q
      WRITE(6,180)
 180   FORMAT(/,"TYPE IN THE CORRECTED VALUE AS PER PREVIOUS")
      PRINT *,"INPUT INSTRUCTIONS."
      READ *,HDES(Q)
 185   CONTINUE
      GO TO 133
 190   IF(ANS.EQ.AYES) GO TO 225
      WRITE(6,191)
191    FORMAT(//,"HOW MANY HELIPORTS ARE TO BE COMPARED (1-10)?")
      READ *,LHELI
      WRITE(6,195)
 195  FORMAT(//,"YOU ARE NOW READY TO INPUT VARIOUS TERRAIN
    + CHARACTERISTICS FOR THE HELIPORT OF CONCERN.")
      PRINT *,"SLOPE CHARACTERISTICS, SOIL THICKNESS AND SOIL TYPE"
      PRINT *,"WILL BE READ.  IF THE SLOPE IS LESS THAN 2%, ENTER"
      PRINT *,"1 - IF IT RANGES FROM 2 TO 10%, ENTER 2 - IF IT"
      PRINT *,"RANGES FROM 10 TO 30%, ENTER 3 - IF RANGE IS 30 TO"
      PRINT *,"40, ENTER 4 - IF GREATER THAN 40%, ENTER 9."
      WRITE(6,203)
203  FORMAT(/,"FOR SOIL THICKNESS, IF THE SOIL IS LESS THAN 2 FEET")
      PRINT *,"THICK, ENTER 1 - IF RANGE IS 2 TO 20 FEET, ENTER 2 -"
      PRINT *,"IF THICKER THAN 20 FEET,ENTER 3."
     WRITE(6,204)
204  FORMAT(/,"FOR SOIL TYPES, IF SAND,ENTER 1 - SILT, ENTER 2 -")
      PRINT *,"CLAY, ENTER 3 - LATERITE (SOFT), ENTER 4 - ROCK/"
      PRINT *,"LATERITE (HARD), ENTER 5."
      DO 205 I=1,LHELI
      WRITE(6,156)I
 156  FORMAT(//,"FOR HELIPORT ",I2)
     PRINT *,"SLOPE:"
```

```
      READ *,SLOP(I)
     PRINT *,"SOIL THICKNESS:"
      READ *,THIC(I)
     PRINT *,"SOIL TYPE:"
      READ *,SOTY(I)
 205  CONTINUE
     WRITE(6,206)
206  FORMAT(//,"NOW INPUT THE SOIL CONDITION, CBR, AND VEGETATION")
      PRINT *,"IF THE SOIL IS DRY, ENTER 1 - IF WET, ENTER 2."
      PRINT *,"ENTER THE CBR DIRECTLY."
      PRINT *,"FOR VEGETATION,  IF THE LAND IS BARREN, ENTER 1"
      PRINT *,"GRASS OR LARGE CULTIVATED FIELDS, ENTER 2"
      PRINT *,"SAVANNA OR SMALL CULTIVATED FIELDS, ENTER 3"
      PRINT*,"WOODLAND OR FOREST WITH SCATTERED FIELDS, ENTER 4"
      PRINT *,"SCRUB, ENTER 5"
      PRINT *,"HEAVY FOREST, ENTER 6"
      PRINT *,"DENSE JUNGLE, ENTER 7"
      DO 215 I=1,LHELI
      WRITE(6,210)I
 210  FORMAT(//,"FOR HELIPORT: ",I2)
     PRINT *,"SOIL CONDITION:"
      READ *,SOCO(I)
     PRINT *,"CBR:"
      READ *,CBR(I)
     PRINT *,"VEGETATION:"
      READ *,VEGE(I)
 215  CONTINUE
       WRITE(6,209)
 209   FORMAT(//,"INPUT REGARDING THE CONSTRUCTION FORCE IS NOW")
       PRINT *,"REQUIRED.  IF THE CONSTRUCTION FORCE IS TO BE OF"
       PRINT *,"ENGINEER CONSTRUCTION, ENTER 1.  IF IT IS TO BE"
       PRINT *,"AN AIRBORNE DIVISION ENGINEER SUPPLEMENTED BY"
       PRINT *,"ENGINEER LIGHT EQUIPMENT COMPANY, ENTER 2.  IF IT"
       PRINT *,"IS TO BE A COMBAT ENGINEER, ENTER 3.  IF IT IS"
       PRINT *,"TO BE AN AIRMOBILE DIVISION ENGINEER, ENTER 4."
     READ *,C
      CONFAC=BATA(C)
      GO TO 400
216  WRITE(6,218)
218  FORMAT(/,"WHAT IS YOUR FILE NAME?")
      READ(5,750)IFIL
 750  FORMAT(A10)
      CALL GETFF(1,IFIL)
      READ(1,217)LHELI,TYPE,C
 217  FORMAT(I2,I1,I1)
      CONFAC=BATA(C)
      READ(1,220)HDES(1),HDES(2),HDES(3),HDES(4)
 220  FORMAT(4F3.0)
      GO TO 133
 225  DO 230 I=1,LHELI
      READ(1,227)SLOP(I),THIC(I),SOTY(I),SOCO(I),CBR(I).VEGE(I)
 227  FORMAT(4F3.0,F4.0,F3.0)
 230  CONTINUE
400   CALL CEFF(HDES,SOCO,SOTY,VEGE,SLOP,THIC,CBR,HDES2,
    + DIFDR,GRADIF,IVCL,RCVCL,CLRIN,CONFAC,TYPE,LHELI)
       CALL LANZON(HDES,HDES2,TYPE)
     PRINT*,"     "
     PRINT*,"     "
     PRINT*,"DO YOU WANT TO DESIGN THE PAVEMENT?  ENTER YES OR NO"
     READ(5,500)NPAV
500  FORMAT(A4)
     IF(NPAV.EQ.ANO)GO TO END
     PRINT*,"     "
     PRINT*,"     "
```

```
      PRINT*,"IF THIS IS A DESIGN FOR A SITE JUST EVALUATED, ENTER THE"
      PRINT*,"SITE NUMBER BELOW.   IF THIS IS A NEW SITE ENTER ZERO(0)."
      READ*,I
      IF(I.GT.0)GO TO  513
      PRINT*,"  "
      PRINT*,"  "
      PRINT*,"WHAT IS THE CBR OF THE SUBGRADE?  ENTERIT AS A WHOLE NUMBER."
      PRINT*,"NUMBER."
      READ*,CBR
      PRINT*,"     "
      PRINT*,"     "
      PRINT*,"WHAT IS THE AREA TO BE SURFACED?  ENTER THE AREA AS A"
      PRINT*,"WHOLE NUMBER IN SQUARE FEET."
      READ*,AREA
      PRINT*,"      "
      PRINT*,"      "
      PRINT*,"WHAT IS THE AREA TO BE DUST PROOFED?  ENTER THE AREA AS A"
      PRINT*,"WHOLE NUMBER IN SQUARE FEET."
      PRINT*,"    "
      PRINT*,"    "
      GO TO 330
513   CBR=CBR(I)
      AREA=AREA(I)
      DAREA=DAREA(I)
      NNO="NO"
      NYES="YES"
330   PRINT*,"     "
      PRINT*,"    "
      PRINT*,"WHAT IS AIRFIELD INDEX OF EXISTING SUBGRADE?"
      READ*,ESUB
      PRINT*,"         "
      PRINT*,"         "
      PRINT*,"SELECT SURFACING REQUIREMENTS.  TABLE 15-1"
      PRINT*,"IN TM5-330 PROVIDES GUIDENCE ON MATTING"
      PRINT*,"SELECTION.  ENTER THE APPROPRIATE CODE FOR"
      PRINT*,"SURFACE DESIRED."
      PRINT*,"         0     NO MAT, MEMBRANE ONLY"
      PRINT*,"         1     MX18B MATTING"
      PRINT*,"         2     MX19  MATTING"
      PRINT*,"         3     AM2   MATTING"
      PRINT*,"         4     ASPHALT CONCRETE"
      READ*, NSURF
      IF(NSURF.EQ.4)GO TO 314
      CALL MAT(NSURF,ESUB,ELSUB,NSTAB,MATX,ITIME,AREA)
      IF(NSTAB.NE.NYES)GO TO 315
      PRINT*,"         "
      PRINT*,"         "
      PRINT*,"IT HAS BEEN DETERMINED THAT STABILIZATION"
      PRINT*,"IS REQUIRED SINCE THE AIRFIELD INDEX OF THE"
      PRINT*,"SUBGRADE IS LESS THAN THE REQUIRED MINIMUM"
      PRINT*,"AIRFIELD INDEX OF:   "
      WRITE(6,300)ELSUB
300   FORMAT(25X,F3.1//)
      PRINT (6,*)"USING TABLE 13-1 IN TM5-330, CAN THE"
      PRINT*,"SUBGRADE BE COMPACTED TO THE REQUIRED MINIMUM"
      PRINT*,"AIRFIELD INDEX?   ENTER YES OR NO."
      READ*,ICOMP
      IF(ICOMP.EQ.NYES)GO TO 315
      PRINT*,"         "
      PRINT*,"         "
      PRINT*,"GO TO TABLE 15-3 IN TM5-330 AND SELECT THE"
      PRINT*,"RECOMMENDED DEPTH OF TREATMENT.  THEN, USING"
      PRINT*,"TABLE 13-7 IN TM5-330, SELECT ONE OF THE FOLLOWING"
      PRINT*,"STABILIZERS AND SELECT QUANTITY REQUIREMENTS:"
```

```
      PRINT*,"        STABILIZER                    CODE"
      PRINT*,"         LIME                            1"
      PRINT*,"         CEMENT                          2"
      PRINT*,"         ASPHALT                         3"
      PRINT*,"FOR ASPHALT CUTBACKS AND EMULSIONS, LOCATE THE"
      PRINT*,"VALUE R IN PARA 13-11 OF TM5-330.  NOW ENTER"
      PRINT*,"THE DATA AS FOLLOWS:................"
      PRINT*,"THICKNESS IN INCHES FOR STABILIZATION,"
      PRINT*,"STABILIZER CODE FROM ABOVE, QUANTITY OF"
      PRINT*,"STABILIZER AS PERCENT,ESTIMATED DRY DENSITY"
      PRINT*,"OF SOIL IN LBS/CUFT,R"
      READ*,THICK,LTYPE,PER,DEN,R
      PRINT*,"YOU ENTERED THE FOLLOWING DATA:"
      PRINT*,"THICKNESS IS  ",THICK
      PRINT*,"STABILIZER TYPE IS  ",LTYPE
      PRINT*,"PERCENT REQUIRED IS  ",PER
      PRINT*,"DRY DENSITY IS  ",DEN
      PRINT*,"R IS  ",R
      PRINT*,"DO YOU WANT TO CHANGE THIS INPUT?"
      PRINT*,"ENTER YES OR NO.  IF YES, ALL ABOVE INPUT"
      PRINT*,"MUST BE REENTERED."
      READ*, INPUT
      IF(INPUT.EQ.NNO)GO TO 316
      PRINT*,"ENTER: THICKNESS,STABILIZER,PERCENT,DRY DENSITY,R"
      READ*,THICK,LTYPE,PER,DEN,R
C       CALCULATE THE STABILIZATION REQUIREMENTS

316   CALL STAB(THICK,LTYPE,PER,DEN,R,AREA,WT,QUAN)
      GO TO 315
C         CALCULATE PAVEMENT THICKNESS AND CONSTRUCTION QUANTITIES

C                FOR FLEXIBLE PAVEMENTS

314    PRINT*,"IS FROST SUSCEPTIBLE DESIGN DESIRED?  ENTER"
       PRINT*,"YES OR NO."
       READ*,NFROST
       IF(NFROST.EQ.NYES)K=1
      IF(K.EQ.1)GO TO 318
      PRINT*,"           "
      PRINT*,"           "
      PRINT*,"WHAT IS THE CBR OF BASE MTL AND (IF APPLICABLE)"
      PRINT*,"THE SUBBASE MTL?  ENTER BOTH VALUES, THE FIRST"
      PRINT*,"MUST BE FOR THE BASE."
      READ*,CBRB,CBRSB
      PRINT*,"THE CBR OF THE BASE IS  ",CBRB
      PRINT*,"THE CBR OF THE SUBBASE IS  ",CBRSB
      PRINT*,"DO YOU WANT TO CHANGE THIS DATA?"
      PRINT*,"IF SO, ENTER YES OR NO."
      READ*,INPUT
      IF(INPUT.EQ.NNO)GO TO 319
      PRINT*,"ENTER CBR OF BASE MTL FOLLOWED BY CBR OF SUBBASE"
      READ*,CBRB,CBRSB
      GO TO 319
318   PRINT*,"BASE AND SUBBASE MTL MUST BE NON-FROST SUSCEPTIBLE"
      PRINT*,"ENTER THE VALUES OF CBR FOR ABOVE MTL'S ONLY IF THEY"
      PRINT*,"MEET THIS CRITERIA.  ENTER THE BASE CBR FOLLOWED "
      PRINT*,"BY SUBBASE CBR(IF APPLICABLE).  IF THIS CRITERIA"
      PRINT*,"CANNOT BE MET, THEN THIS PROGRAM MUST TERMINATE BY"
      PRINT*,"ENTERING ZERO'S."
      READ*,CBRB,CBRSB
```

```
319  IF(CBRB.GT.0)GO TO 320
     IF(CBRB.EQ.0)GO TO 325
320  IF(CBRB.GT.79.9)GO TO 321
     PRINT*,"THIS PROGRAM MUST TERMINATE SINCE THE"
     PRINT*,"CBR OF BASE MTL MUST BE AT LEAST 80."
     GO TO 325
     PRINT*,"        "
     PRINT*,"        "
321  PRINT*,"WHAT IS THE ESTIMATED PLASTIC INDEX?"
     PRINT*,"OF THE SUBGRADE?"
     READ*,PI
     CALL ASPHA(K,CBR,CBRB,CBRSB,PI,ATHICK,BTHICK,AC,DUSTCK,QTIME,QTY
    +,AREA)
     PRINT*,"            "
     PRINT*,"            "
315  PRINT*,"DO YOU WANT A DUST PALLIATIVE?"
     PRINT*,"ENTER YES OR NO."
     READ*,IPAL
     IF(IPAL.EQ.NNO)GO TO 331
     PRINT*,"            "
     PRINT*,"            "
     PRINT*,"FROM TABLE 13-6 IN TM5-330, SELECT THE APPROPRIATE"
     PRINT*,"STABILIZER AND APPLICATION RATE. ENTER THE"
     PRINT*,"STABILIZER NAME, APPLICATION RATE UNDER PROPER UNITS"
     PRINT*,"*N*A*M*E**          *GAL          *LBS"
     READ(5,367)NAME,GAL,ALBS
367  FORMAT(A10,8X,F4.3,8X,F4.3)
     CALL DUST(DAREA,GAL,ALBS,ITIMED,QTYDUS)
331  CALL OUTPUT(NSURF,THICK,LTYPE,PER,AREA,WT,QUAN,MATX,ITIME,DAREA
    +,GAL,ALBS,IPAL,ITIMED,QTYDUS,AC,ATHICK,BTHICK,QTIME,QTY,NAME,
    *NSTAB)
     PRINT*,"         "
     PRINT*,"         "
325  PRINT*,"DO YOU WANT TO DESIGN ANOTHER SITE?"
     PRINT*,"ENTER YES OR NO."
     READ*,IDES
     IF(IDES.EQ.NYES)GO TO 330
     STOP
     END
     SUBROUTINE MAT(NSURF,ESLB,ELSUB,NSTAB,MATX,ITIME,AREA)
     PRINT*,"         "


     PRINT*,"         "
     PRINT*,"FROM FIGUIRES D-20 TO D-23 IN TM5-330, DETERMINE THE"
     PRINT*,"MINIMUM AIRFIELD INDEX REQUIRED FOR MATTING"
     PRINT*,"SELECTED.  USE THE HEAVIEST HELO TO OPERATE "
     PRINT*,"FROM AREA"
     READ*,ELSUB
     IF(ELSUB.GT.ESLB)NSTAB="YES"
     IF(NSURF.EQ.0) GO TO 15
     IF(NSURF.EQ.1) GO TO14
     IF(NSURF.EQ.2) GO TO 13
     CALCULATE QUANTITY OF AM2 MATTING REQUIRED AND MANHOURS TO INSTALL
```

```
      MATX=AREA/288
      ITIME=AREA/573
      GO TO 16
C     CALCULATE THE QUANTITY OF MX19 MATTING REQUIRED AND MANHOURS TO INSALL

   13 MATX=AREA/534.4
      ITIME=AREA/350
      GO TO 16
C     CALCULATE QUANTITY OF MX18 MATTING REQUIRED AND MANHOURS TO INSTALL

   14 MATX=AREA/432
      ITIME=AREA/574
      GO TO 16
C     CALCULATE QUANTITY OF T-17 MEMBRANE REQUIRED

   15 MATX=AREA
   16 RETURN
      END

      SUBROUTINE STAB(THICK,LTYPE,PER,R,AREA,WT,QUAN)
C     CALCULATE WT OF STABILIZER AND QUANTITY OF SOIL TO BE TREATED

      IF(LTYPE.EQ.3) GO TO 13
      WT=AREA*(THICK/12.)*DEN*(PER/100.)
      QUAN=(AREA/27.)*(THICK/12.)
      GO TO 14

   13 WT=AREA*(THICK/12.)*DEN*(PER/100.)*(100/R)
      QUAN=(AREA/27.)*(THICK/12.)
   14 RETURN
      END
      SUBROUTINE DUST(DAREA,GAL,ALBS,ITIMED,QTYDUS)
C     CALCULATE QUANTITY OF PALLIATIVE REQUIRED AND MANHOURS TO APPLY

      DAREA=DAREA/9.
      IF(ALBS.EQ.0)GO TO 13
      QTYDUS=DAREA*ALBS
      ITIMED=QTYDUS/2500
```

```
      GO TO 14
13    QTYDUS=CAREA*GAL
      ITIMED=QTYDUS/2500
14    RETURN
      END
      SUBROUTINE ASPHA(K,CBR,CBRB,CBRSB,PI,ATHICK,BTHICK,AC,
     +DESTCK,GTIME,QTY,AREA)
      WRITE(6,1)
 1    FORMAT(//)
      PRINT*,"FROM TABLE D-37 FOR THE HEAVIEST HELO AND THE"
      PRINT*,"CBR OF THE COMPACTED SUBGRADE.  SELECT THICKNESS"
      PRINT*,"IN WHOLE INCHES OF THE PAVEMENT AND ENTER IT NOW."
      READ*,ATHICK
      IF(CBRSB.EQ.0.0)GO TO 13
      WRITE(6,2)
 2    FORMAT(///)
      PRINT*,"FROM THE TABLE C-37, FOR THE CBR OF THE SUB-"
      PRINT*,"BASE SELECT THICKNESS OF THE PAVEMENT IN WHOLE INCHES"
      PRINT*,"AND ENTER THAT NOW."
      READ*,BTHICK
      FILL=0.0
      IF(PI.GT.5)FILL=4.0
      DESTCK=ATHICK+BTHICK-1.5
      IF(DESTCK.GT.4.) GO TO 13
      BTHICK=0.0
      ATHICK=4.
      AC=1
      GO TO 14
13    IF(DESTCK.GT.8.) GO TO 15
      BTHICK=0.
      ATHICK=DESTCK
      AC=2
      GO TO 14
15    ATHICK=4.
      BTHICK=DESTCK-4.
      AC=3
14    IF(K.NE.1) GO TO 16
      WRITE(6,3)
 3    FORMAT(///)
      PRINT*,"SINCE YOU HAVE REQUESTED FROST SUSCEPTIBLE"
      PRINT*,"DESIGN, ENTER PAVEMENT THICKNESS IN WHOLE INCHES"
      PRINT*,"FOR THE SOIL CLASSIFICATION OF THE SUBGRADE FROM"
      PRINT*,"TABLES 13-15 IN TM5-330.  USE WEIGHT OF HEAVIEST"
      PRINT*,"HELO."
      READ*,DESTCK
      IF(CBRSB.EQ.0.) GO TO 17
      BTHICK=DESTCK-ATHICK-1.5-FILL
      FILL=4.
      AC=4
      GOTO 16
17    ATHICK=DESTCK-5.5
      BTHICK=0.
      FILL=4.
      AC=5
16    QAC=(AREA*1.5/12.)/27.
       PRINT*,"QAC IS      ",QAC
      QATCK=(AREA*ATHICK/12.)/27.
       PRINT*,"QATCK IS    ", QATCK
      QBTCK=(AREA*BTHICK/12.)/27.
       PRINT*,"QBTCK IS   ",QBTCK
      QFILL=(AREA*FILL/12.)/27.
       PRINT*,"QFILL IS    ", QFILL
C     CALCULATE THE TIME REQUIRED IN MANHOURS FOR SUBBASE AND BASE
```

```
      QTY=QATCK+QBTCK+QFILL
       PRINT*,"QTY IS    ", QTY
      QTIME=(QTY/1000.)*370.
       PRINT*,"QTIME IS  ", QTIME
      QTA=AREA*130.
       PRINT*,"QTA IS  ", QTA
      QTIME=QTIME+QTA
      RETURN
      END
      SUBROUTINE OUTPUT(NSURF,THICK,LTYPE,PER,AREA,WT,QUAN,MATX,ITIME,
     *DAREA,GAL,ALBS,IFAL,ITIMED,QTYDUS,AC,ATHICK,BTHICK,QTIME,QTY,NAME,
     *NSTAB)
      NYES="YES"
      NNO="NO"
      IF(NSURF.EQ.0)GO TO 13
      IF(NSURF.EQ.1)GO TO 14
      IF(NSURF.EQ.2)GO TO 14
      IF(NSURF.EQ.3)GO TO 16
      IF(AC.LT.2)GO TO 17
      IF(AC.EQ.3)GO TO 18
      IF(AC.EQ.4)GO TO 19
      WRITE(6,1)AREA
    1 FORMAT(//,"YOU SELECTED ASPHALT PAVEMENT FOR AREA OF:  ",F10.1,
     +/,"SINCE DESIGN IS NON-FROST SUSCEPTIBLE, THE PAVEMENT IS:"/)
      WRITE(6,2)ATHICK
    2 FORMAT("ASPHALT THICKNESS  1.5 INCHES",/,"BASE THICKNESS",2X,
     +F3.1,2X,"INCHES",/,"FILTER THICKNESS IS  4.0 INCHES",//)
      PRINT*,"BASE MTL MUST BE COMPACTED TO 100%.  THE TOP SIX INCHES"
      PRINT*,"OF SUBGRADE MUST BE COMPACTED TO 95%.  THE FILTER MTL"
      PRINT*,"MUST BE A COARSE GRAINED SAND."
      WRITE(6,3) QTY,QTIME
    3 FORMAT(//,"THIS DESIGN REQUIRES ",F10.1," CUBIC YDS OF BASE AND",/,
     +"FILTER MATERIAL AND WILL REQUIRE ",I10," MANHOURS TO COMPLETE"//)
      GO TO 35
   19 WRITE(6,1)AREA
      WRITE(6,4)ATHICK,BTHICK
    4 FORMAT("ASPHALT THICKNESS 1.5 INCHES",/,"BASE THICKNESS ",F3.1," I
     +NCHES",/,"SUBBASE THICKNESS  ",F3.1," INCHES",/
     +,"FILTER THICKNESS IS 4.0 INCHES",//)
      PRINT*,"BASE AND SUBASE MUST BE COMPACTED TO 100%.  TOP SIX"
      PRINT*,"INCHES OF SUBGRADE MUST BE COMPACTED TO 95%.  FILTER"
      PRINT*,"MATERIAL IS A COARSE GRAINED SAND."
      WRITE(6,5)QTY,QTIME
    5 FORMAT(/,"THIS DESIGN REQUIRES ",F10.1," CUBIC YDS OF BASE,SUBBASE,
     +,",/,"AND FILTER MTL AND REQUIRES ",I10," MANHOURS TO COMPLETE."
     +//)
      GO TO 35
   18 WRITE(6,6) AREA
    6 FORMAT(//,"YOU SELECTED ASPHALT PAVEMENT FOR AN AREA OF  ",F10.1,
     +/,"SQUARE FT.  THE DESIGN IS:")
      WRITE(6,7)ATHICK
    7 FORMAT(/,"ASPHALT THICKNESS 1.5 INCHES",/,"BASE THICKNESS  ",F3.1,
     +"INCHES",/,"SUBASE THICKNESS  ",F3.1," INCHES"//)
      PRINT*,"BASE AND SUBASE MUST BE COMPACTED TO 100%.  TOP SIX"
      PRINT*,"INCHES OF SUBGRADE MUST BE COMPACTED TO 95%."
      WRITE(6,8)QTY,QTIME
    8 FORMAT(/,"THIS DESIGN REQUIRES",F10.1," CUBIC YARDS OF BASE AND",
     +/,"SUBBASE MTL AND WILL REQUIRE ",I10," MANHOURS TO COMPLETE."//)
      GO TO 35
   17 WRITE(6,6)AREA
      WRITE(6,9)ATHICK
    9 FORMAT(//,"ASPHALT THICKNESS IS 1.5 INCHES",/,"BASE THICKNESS",
     +F3.1," INCHES",//)
      PRINT*,"BASE MTL MUST BE COMPACTED TO 100%.  TOP SIX INCHES OF"
```

```
      PRINT*,"SUBGRADE MUST BE COMPACTED TO 95%."
      WRITE(6,21)QTY,QTIME
21    FORMAT(//,"THIS DESIGN REQUIRES ",F10.1,"CUBIC YARDS OF BASE MTL",
     +/,"AND WILL REQUIRE ",I10," MANHOURS TO COMPLETE.",//)
      GO TO 35
16    WRITE(6,22)AREA
22    FORMAT(//,"YOU SELECTED THE AM2 MATTING SYSTEM FOR AN AREA OF",/,
     +F10.1," SQUARE FEET.",/)
      WRITE(6,23)MATX,ITIME
23    FORMAT("THIS SURFACE REQUIRES ",I10," BUNDLES OF MATTING AND",/,
     +I10,"MANHOURS TO INSTALL."//)
      GO TO 20
15    WRITE(6,24)AREA
24    FORMAT(//,"YOU SELECTED THE MX19 MATTING SYSTEM FOR AN AREA OF",
     +F10.1," SQUARE FT."/)
      WRITE(6,23)MATX,ITIME
      GO TO 20
14    WRITE(6,25)AREA
25    FORMAT(//,"YOU SELECTED THE MX18B MATTING SYSTEM FOR AN AREA OF",
     +/,F10.1," SQUARE FT."//)
      WRITE(6,23)MATX,ITIME
      GO TO 20
13    WRITE(6,26)AREA
26    FORMAT(//,"YOU SELECTED THE MEMBRANE SYSTEM FOR AN AREA OF",/,
     +F10.1," SQUARE FT.  THE TIME TO INSTALL IS UNKNOWN."//)
      GO TO 20
20    IF(NSTAB.NE.NYES)GO TO 35
      IF(LTYPE.EQ.2) GO TO 31
      IF(LTYPE.EQ.3) GO TO 32
      WRITE(6,33)PER ,THICK
33    FORMAT(//,"YOU ARE TO APPLY ",F4.1," PERCENT LIME TO SOIL",/,
     +"FOR A DEPTH OF TREATMENT OF ",F3.1," INCHES.",//)
      WRITE(6,34)WT,QUAN
34    FORMAT(//,"THIS WILL REQUIRE ",F10.2," POUNDS OF STABILIZER",/,
     +"TO TREAT  ",F10.1," CUBIC YARDS OF SOIL.",//)
      GO TO 35
31    WRITE(6,36)PER,THICK
36    FORMAT(//,"YOU ARE TO APPLY  ",F4.1," PERCENT CEMENT TO THE SOIL"
     +,/,"FOR A DEPTH OF TREATMENT OF ",F3.1," INCHES."//)
      WRITE(6,34)WT,QUAN
      GO TO 35
32    WRITE(6,37)PER,THICK
37    FORMAT(//"YOU ARE TO APPLY ",F4.1," PERCENT ASPHALT TO THE SOIL",
     +/,"FOR A DEPTH OF TREATMENT OF ",F3.1," INCHES."//)
      WRITE (6,34)WT,QUAN
35    IF(IPAL.NE.NYES)GO TO 50
      WRITE(6,43)NAME
43    FORMAT(//,"YOU SELECTED ",A10," AS A DUST PALLIATIVE.")
      IF(ALBS.EQ.0)GO TO 40
      WRITE(6,38)DAREA,ALBS
38    FORMAT("AN AREA OF ",F10.2," SQUARE YARDS WILL BE TREATED",/,
     +"AT THE RATE OF ",F3.2," POUNDS PER SQUARE YARD.",/)
      WRITE(6,39)QTYDUS,ITIMEC
39    FORMAT("THIS OPERATION WILL REQUIRE ",F10.2," POUNDS OF",/,
     +"STABILIZER AND REQUIRE ",I10," MANHOURS TO APPLY.",/)
      GO TO 50
40    WRITE(6,41)DAREA,GAL
41    FORMAT("AN AREA OF ",F10.2," SQUARE YARDS WILL BE TREATED AT",/,
     +"THE RATE OF ",F3.2," GALLONS PER SQUARE YARD.",/)
      WRITE(6,42)QTY,ITIMEC
42    FORMAT("THIS OPERATION WILL REQUIRE ",F10.2," GALLONS OF",/,
     +"STABILIZER AND REQUIRES ",I10," MANHOURS TO APPLY.",//)
50    RETURN
      END
```

```
      SUBROUTINE CEFF(HDES,SOCC,SOTY,VEGE,SLOP,THIC,CBR,HDES2,
     + DIFDR,GRADIF,IVOL,ROVOL,CLRIN,CONFAC,TYPE,LHELI)
      DIMENSION HDES(4),SOCC(10),SOTY(10),VEGE(10),SLOP(10),THIC(10)
      DIMENSION CBR(10),HDES2(4),CEFFRT(10,4),DIFDR(4,4),GRADIF(5,2)
      DIMENSION IVOL(4),ROVOL(3,4),CLRIN(6,4),GRAFAC(10)
      DO 420 I=1,LHELI
      E=THIC(I)
      S=VEGE(I)
      T=SLOP(I)
      X=SOCC(I)
      U=SOTY(I)
      SOPRO=(100-ROVOL(E,T))/100
      VOLSO=IVOL(T)*SOPRO
      VOLRO=IVOL(T)*ROVOL(E,T)/100
      GRAFAC(I)=VOLSO*GRADIF(U,X)+VOLRO*1.5
      IF(HDES(1).GT.0)GO TO 421
      CEFFRT(I,1)=0
  417 IF(HDES(2).GT.0)GO TO 401
      CEFFRT(I,2)=0
      GO TO 418
  401 IF(HDES(2).GT.90)GO TO 445
      GO TO 427
  418 IF(HDES(3).GT.0)GO TO 402
      CEFFRT(I,3)=0
      GO TO 419
  402 IF(HDES(3).GT.90)GO TO 449
      GO TO 432
  419 IF(HDES(4).GT.0)GO TO 403
      CEFFRT(I,4)=0
      GO TO 420
  403 IF(HDES(4).GT.90)GO TO 453
      GO TO 437
  420 CONTINUE
      GO TO 460
 421  IF(TYPE.EQ.0)GO TO 423
      IF(CBR(I).GE.4)GO TO 422
      CEFFRT(I,1)=((0.32*GRAFAC(I)+.032*DIFOR(U,T)+.038*CLRIN(S,T))
     + *CONFAC)*HDES2(1)
      GO TO 417
  422 CEFFRT(I,1)=((0.13*GRAFAC(I)+.013*DIFOR(U,T)+.016*CLRIN(S,T)
     + )*CONFAC)*HDES2(1)
      GO TO 417
  423 IF(CBR(I).GE.4)GO TO 424
      CEFFRT(I,1)=((0.25*GRAFAC(I)+.025*DIFOR(U,T)+.03*CLRIN(S,T))
     + *CONFAC)*HDES2(1)
      GO TO 417
  424 CEFFRT(I,1)=((0.11*GRAFAC(I)+.011*DIFOR(U,T)+.013*
     + CLRIN(S,T))*CONFAC)*HDES2(1)
      GO TO 417
  427 IF(TYPE.EQ.0)GO TO 429
      IF(CBR(I).GE.4)GO TO 428
      CEFFRT(I,2)=((0.42*GRAFAC(I)+.042*DIFOR(U,T)+.05*CLRIN(S,T))
     + *CONFAC)*HDES2(2)
      GO TO 418
  428 CEFFRT(I,2)=((0.23*GRAFAC(I)+.023*DIFOR(U,T)+.028*
     + CLRIN(S,T))*CONFAC)*HDES2(2)
      GO TO 418
  429 IF(CBR(I).GE.4)GO TO 430
      CEFFRT(I,2)=((0.4*GRAFAC(I)+.04*DIFOR(U,T)+.048*
     + CLRIN(S,T))*CONFAC)*HDES2(2)
      GO TO 418
  430 CEFFRT(I,2)=((.18*GRAFAC(I)+.018*DIFOR(U,T)+.048*
     + CLRIN(S,T))*CONFAC)*HDES2(2)
      GO TO 418
```

```
 432  IF(TYPE.EQ.0)GO TC 434
      IF(CBR(I).GE.4)GO TC 433
      CEFFRT(I,3)=((.65*GRAFAC(I)+.065*DIFDR(U,T)+.078*
    + CLRIN(S,T))*CONFAC)*HDES2(3)
      GO TC 419
 433  CEFFRT(I,3)=((.29*GRAFAC(I)+.029*DIFDR(U,T)+.035*
    + CLRIN(S,T))*CONFAC)*HDES2(3)
      GO TC 419
 434  IF(CBR(I).GE.4)GO TC 435
      CEFFRT(I,3)=((1.3*GRAFAC(I)+.13*DIFDR(U,T)+.16*
    + CLRIN(S,T))*CONFAC)*HDES2(3)
      GC TC 419
 435  CEFFRT(I,3)=((.58*GRAFAC(I)+.058*DIFDR(U,T)+.07*
    + CLRIN(S,T))*CONFAC)*HDES2(3)
      GC TC 419
 437  IF(TYPE.EQ.0)GO TC 439
      IF(CBR(I).GE.4)GO TO 438
      CEFFRT(I,4)=((1.5*GRAFAC(I)+.15*DIFDR(U,T)+.18*
    + CLRIN(S,T))*CONFAC)*HDES2(4)
      GC TC 420
 438  CEFFRT(I,4)=((.66*GRAFAC(I)+.066*DIFDR(U,T)+.079*
    + CLRIN(S,T))*CONFAC)*HDES2(4)
      GC TC 420
 439  IF(CBR(I).GE.4)GO TO 440
      CEFFRT(I,4)=((1.1*GRAFAC(I)+.11*DIFDR(U,T)+.13*
    + CLRIN(S,T))*CONFAC)*HDES2(4)
      GO TC 420
440   CEFFRT(I,4)=((.43*GRAFAC(I)+.043*DIFDR(U,T)+.05*
    + CLRIN(S,T))*CONFAC)*HDES2(4)
      GO TO 420
 445  IF(TYPE.EQ.0)GO TO 446
      IF(CBR(I).GE.4)GO TC 447
      CEFFRT(I,2)=(4.7*GRAFAC(I)+.47*DIFDR(U,T)+.56*
    + CLRIN(S,T))*CONFAC
      GO TC 418
 447  CEFFRT(I,2)=(1.7*GRAFAC(I)+.17*DIFDR(U,T)+.19*
    + CLRIN(S,T))*CONFAC
      GO TC 418
 446  IF(CBR(I).GE.4)GO TO 448
      CEFFRT(I,2)=(3.1*GRAFAC(I)+.31*DIFDR(U,T)+.37*
    + CLRIN(S,T))*CONFAC
      GO TC 418
 448  CEFFRT(I,2)=(1.2*GRAFAC(I)+.12*DIFDR(U,T)+.15*
    + CLRIN(S,T))*CONFAC
      GO TC 418
 449  IF(TYPE.EQ.0)GO TO 451
_449  IF(TYPE.EQ.0)GO TC 451
_449  IF(TYPE.EQ.0)GO TC 451
      IF(CBR(I).GE.4)GO TO 450
      CEFFRT(I,3)=(17.7*GRAFAC(I)+1.77*DIFDR(U,T)+2.12*
    + CLRIN(S,T))*CONFAC
      GO TC 419
 450  CEFFRT(I,3)=(10.0*GRAFAC(I)+1.0*DIFDR(U,T)+1.2*
    + CLRIN(S,T))*CONFAC
      GO TC 419
 451  IF(CBR(I).GE.4)GO TC 452
      CEFFRT(I,3)=(10.7*GRAFAC(I)+1.07*DIFDR(U,T)*1.29*
    + CLRIN(S,T))*CONFAC
      GO TC 419
 452  CEFFRT(I,3)=(4.2*GRAFAC(I)+.42*DIFDR(U,T)+.51*
    + CLRIN(S,T))*CONFAC
      GO TC 419
 453  IF(CBR(I).GE.4)GO TO 454
      CEFFRT(I,4)=(14.4*GRAFAC(I)+1.44*DIFDR(U,T)+1.73*
```

```
     + CLRIN(S,T))*CONFAC
       GO TO 420
 454   CEFFRT(I,4)=(8.0*GRAFAC(I)+.8*DIFOR(U,T)+.96*
     + CLRIN(S,T))*CONFAC
       GO TO 420
 460   WRITE(6,461)
 461   FORMAT(//,"THE CONSTRUCTION EFFORTS FOR THE HELIPORTS")
       PRINT *,"OF CONCERN WILL BE PRINTED IN SUCCESSIVE ORDER.  THE"
       PRINT *,"UNITS ARE 'BATALLION-DAYS'"
       WRITE(6,466)
 466   FORMAT(//,"*****************************************",//)
       IF(TYPE.EQ.1) GO TO 462
       PRINT *,"THE HELIPORT TO BE DESIGNED IS IN THE FORWARD AREA"
       GO TO 463
 462   PRINT *,"THE HELIPORT TO BE DESIGNED IS IN THE SUPPORT AREA"
 463   DO 460 I=1,LHELI
       WRITE(6,465)I
 465   FORMAT(//,"CONSTRUCTIVE EFFORT FOR HELIPORT ",I2)
       CONEFF=0
       DO 475 J=1,4
       WRITE(6,470)J,CEFFRT(I,J)
 470   FORMAT(/,"FOR HELICOPTER TYPE: ",I1," EFFORT IS: ",
     + F6.2," BATALLION DAYS.")
       CONEFF=CONEFF+CEFFRT(I,J)
 475   CONTINUE
       WRITE(6,720)
 720   FORMAT(//,"TOTAL CONSTRUCTIVE EFFORT FOR THE HELIPORT IS:")
       WRITE(6,476)CONEFF
 476   FORMAT(/,"*****",F7.2," BATALLION DAYS *****",//////////)
 460   CONTINUE
       RETURN
       END
       SUBROUTINE LANZON(HDES,HDES2,TYPE)
       DIMENSION HDES(4),HDES2(4)
       DIMENSION PADLEN(4),PADWID(4),PADGRA(2),CLRGRA(2),ARLEN(2,4),
     + ARWID(2,4),RWAWID(2),RWACLR(2),TAXWID(2),PARLEN(4),PARWID(4)
       DIMENSION TAHCSP(4),LATCLR(2,4),CCSPAC(2,4),HOVWID(2,4),CLCLR(2)
      DIMENSION HECLZO(2)
       REAL LATCLR
      DATA HECLZO/250.,270./
       DATA PADLEN/12.,20.,50.,50./
       DATA PADWID/12.,20.,25.,50./
       DATA PADGRA/3.,1.5/
       DATA CLRGRA/10.,5./
       DATA ARLEN/72.,105.,100.,120.,150.,150.,150.,150./
       DATA ARWID/72.,105.,100.,120.,125.,150.,150.,150./
       DATA RWAWID/25.,50./
       DATA RWACLR/125.,135./
       DATA TAXWID/25.,40./
       DATA PARLEN/12.,20.,50.,50./
       DATA PARWID/12..20.,25.,50./
       DATA TAHCSP/10.,20.,20.,20./
       DATA LATCLR/25.,25.,45.,55.,65.,75.,55.,65./
       DATA CCSPAC/40.,55.,75.,80.,150.,175.,150.,175./
       DATA HOVWID/75.,100.,140.,200.,180.,240.,200.,250./
       DATA CLCLR/125.,135./
       PRINT *,"DOES YOUR HELIPORT INCLUDE A RUNWAY/TAXIWAY SYSTEM,"
       PRINT *,"PADS/HOVERLANE SYSTEM, OR SIMPLY PADS?"
       PRINT *,"IF RUNWAY/TAXIWAY,ENTER 1 ... IF PADS ENTER 0 ..."
       PRINT *,"IF TAXI/HOVERLANE, ENTER 2."
       READ *,HPORT
       IF(TYPE.EQ.1) GO TO 740
       WRITE(6,730)
 730   FORMAT(////,"*** FORWARD AREA HELIPORT SPECIFICATIONS ***")
```

```
      GO TO 750
740   WRITE(6,745)
745   FORMAT(////,"*** SUPPORT AREA HELIPORT SPECIFICATIONS ***")
 750  IF(HPORT.EQ.1)GO TO 560
      IF(HPORT.EQ.2)GO TO 585
      PADAREA=0
      DO 500 I=1,4
      IF(HDES(I).EQ.0)GO TO 500
      L=I
      IF(TYPE.EQ.1)GO TO 515
      PRINT *,"------------ TYPE ",L," HELICOPTERS ------------"
      PRINT *,"LANDING PAD SPECIFICATIONS ARE:"
      WRITE(6,505)PADLEN(L),PADWID(L),PADGRA(1),CLRGRA(1)
 505  FORMAT(/,"LENGTH: ",F4.0,/,"WIDTH: ",F4.0,/,
     + "PAD GRADE (DIR OF APP/DEP): ",F3.1,/,
     + "MAX CLEAR AREA GRADE: ",F3.0,//)
      PRINT *,"LANDING AREA DIMENSIONS ARE:"
      WRITE(6,510)ARLEN(1,L),ARWID(1,L)
 510  FORMAT(/,"LENGTH: ",F4.0,/,"WIDTH: ",F4.0,//)
      PRINT *,"NUMBER OF TYPE ",L," PADS IS: ",HDES2(L)
      PDAR=(PADLEN(L)*PADWID(L))*HDES2(L)
      PADAREA=PADAREA+PDAR
      GO TO 500
 515  PRINT *,"------------ TYPE ",L," HELICOPTERS ------------"
      PRINT *,"LANDING PAD SPECIFICATIONS ARE:"
      WRITE(6,520)PADLEN(L),PADWID(L),PADGRA(2),CLRGRA(2)
 520  FORMAT(/,"LENGTH: ",F4.0,/,"WIDTH: ",F4.0,/,
     + "PAD GRADE (DIR OF APP/DEP): ",F4.1,/
     + ,"MAX CLEAR AREA GRADE: ",F4.0,//)
      PRINT *,"LANDING AREA DIMENSIONS ARE:"
      WRITE(6,525)ARLEN(2,L),ARWID(2,L)
 525  FORMAT(/,"LENGTH: ",F4.0,/,"WIDTH: ",F4.0,//)
      PRINT *,"NUMBER OF TYPE ",L," PADS IS: ",HDES2(L)
      PDAR=(PADLEN(L)*PADWID(L))*HDES2(L)
      PADAREA=PADAREA+PDAR
 500  CONTINUE
      IF(TYPE.EQ.0)GO TO 550
      PRINT *,"SHOULDER WIDTH IS 10 FEET."
      WRITE(6,501)
501   FORMAT(/,"GRADE OF SHOULDER IN DIRECTION OF APPROACH OR")
      PRINT *,"DEPARTURE IS 1.5 PERCENT."
      WRITE(6,502)
502   FORMAT(/,"TRANSVERSE GRADE OF SHOULDER:")
      PRINT *,"             MAX OF 3 PERCENT ... MIN OF 2 PERCENT"
      GO TO 555
550   WRITE(6,735)
735   FORMAT(////,"SHOULDERS ARE NOT OF CONCERN FOR FORWARD ")
      PRINT *,"AREA HELIPORTS."
555   WRITE(6,503)
503   FORMAT(/,"APPROACH/DEPARTURE ZONE SURFACE RATIO IS 10:1",/)
     PRINT *,"APPROACH/DEPARTURE ZONE LENGTH IS 1500 FEET."
     PRINT *,"APPROACH/DEPARTURE ZONE WIDTH, OUTER EDGE,"
      PRINT *,"IS 500 FEET."
     WRITE(6,504)
504   FORMAT(/,"ZONE WIDTH AT EDGE OF LANDING AREA IS EQUAL TO")
      PRINT *,"SPECIFIED LANDING AREA WIDTH."
     WRITE(6,556)
556   FORMAT(/,"TAKEOFF SAFETY ZONE LENGTH IS 500 FEET....")
      PRINT *,"WIDTH IS SAME AS APPROACH/DEPARTURE ZONE."
      GO TO 598
560   M=0
      IF(HDES(4).GT.0)M=2
      IF(M.EQ.2)GO TO 561
      M=1
```

```
561   WRITE(6,562)
562   FORMAT(//,"RUNWAY CONFIGURATIONS ARE NORMALLY SPECIFIED")
       PRINT *,"FOR SUPPORT AREA HELIPORTS WHERE TYPE 3 OR TYPE 4"
       PRINT *,"HELICOPTERS ARE TO BE SERVED."
       PRINT *,"RUNWAY LENGTHS ARE 450 FEET IN BOTH CASES."
       WRITE(6,565)RWAWID(M)
 565   FORMAT(/,"RUNWAY WIDTH IS: ",F4.0," FT")
       RWAYSUR=RWAWID(M)*450
       WRITE(6,570)TAXWID(M)
570   FORMAT(/,"TAXIWAY WIDTHS ARE: ",F4.0," FT",/,
     +"LENGTH IS GIVEN LATER IN THE SPECIFICATIONS.",//)
      PRINT *,"CLEARENCE FROM RUNWAY AND TAXIWAY CENTERLINE TO"
       PRINT *,"FIXED OR MOVABLE OBSTACLES: ",RWACLR(M)
      WRITE(6,573)
573   FORMAT(//,"LONGITUDINAL GRADE OF RUNWAYS AND SHOULDERS IS")
       PRINT *,"PLUS OR MINUS 2 PERCENT."
        ORUWID=RWAWID(M)+10.
       WRITE(6,760)
 760    FORMAT(//,"HELIPORT OVERRUN LENGTH IS 100 FT AND WIDTH")
        PRINT *,"IS ",ORUWID," FT.  THE LONGITUDINAL GRADE IS"
        PRINT *,"2 PERCENT WITH THE TRANSVERSE GRADE RANGING"
        PRINT *,"FROM 2 TO 3 PERCENT."
        WRITE(6,765)
 765    FORMAT(//,"HELIPORT CLEAR ZONE REQUIREMENTS ARE A LENGTH")
        PRINT *,"OF 100 FT AND A WIDTH OF ",HECLZO(M)," FT."
        PRINT *,"CLEAR ZONE GRADE OUTSIDE OF OVERRUN AND SHOULDERS"
        PRINT *,"IS 5 PERCENT."
      WRITE(6,574)
574   FORMAT(/,"LONGITUDINAL GRADE OF TAXIWAY IS 2 PERCENT.",/)
      PRINT *,"TRANSVERSE GRADE OF RUNWAY AND TAXIWAY:"
       PRINT *,"                 MAX OF 1.5 PERCENT ... MINOF 0.5 PERCENT"
      WRITE(6,581)
581   FORMAT(//,"MAX CLEAR AREA SLOPE IS 5 PERCENT.",//)
      PRINT *,"LONGITUDINAL GRADE OF TAXIWAYS AND SHOULDERS IS 2 %"
      WRITE(6,582)
582   FORMAT(/,"TRANSVERSE GRADE OF TAXIWAYIS:")
       PRINT *,"          MAX OF 1.5 PERCENT ... MIN OF 0.5 PERCENT."
      WRITE(6,583)
583   FORMAT(/,"SHOULDER WIDTH IS 10 FEET.",/)
      PRINT *,"TRANSVERSE GRADES OF TAXIWAY SHOULDERS ARE:"
       PRINT *,"          MAX OF 3 PERCENT ... MIN OF 2 PERCENT."
      WRITE(6,584)
584   FORMAT(/,"CLEARENCE FROM TAXIWAY CENTERLINE TO FIXED OR")
       PRINT *,"MOVABLE OBSTACLES IS: ",CLCLR(M)," FT."
      WRITE(6,586)
586   FORMAT(/,"GRADE IN TAXIWAY CLEAR ZONE IS 5 PERCENT.")
571   WRITE(6,587)
587   FORMAT(//,"*** PARKING PAD SPECIFICATIONS ***",/)
       TAXWYLN=0
       PADAREA=0
       DO 576 L=1,4
       IF(HDES(L).EQ.0)GO TO 576
      PRINT *,"FOR HELICOPTER TYPE ",L,":"
       WRITE(6,575)PAPLEN(L),PARWID(L),TAHOSP(L)
 575   FORMAT(/,"LENGTH: ",F4.0,/,"WIDTH: ",F4.0,///,
     + "SPACING FROM EDGE OF TAXI/HOVERLANE TO EDGE OF PARKING PAD: ",
     + F4.0,//)
      PKAR=(PARLEN(L)*PARWID(L))*HDES2(L)
      PADAREA=PADAREA+PKAR
      IF(TYPE.EQ.1)GO TO 580
      PRINT *,"LATERAL CLEARENCE FROM REAR AND SIDES OF PARKING"
       PRINT *,"PAD TO FIXED OR MOVABLE OBSTACLES, EXCLUDING OTHER"
       PRINT *,"AIRCRAFT: ",LATCLR(1,L)," FT."
      WRITE(6,588)CCSPAC(1,L)
```

```
588  FORMAT(//,"CENTER-TO-CENTER SPACING OF PARKING PADS IS:",F5.0,//)
      SPAC=(HDES2(L)/2 +0.5)*CCSPAC(1,L)
      TAXWYLN=TAXWYLN+SPAC
      GO TO 576
580  PRINT *,"LATERAL CLEARENCE FROM REAR AND SIDES OF PARKING"
      PRINT *,"PAD TO FIXED OR MOVABLE OBSTACLES,EXCEPTING OTHER"
      PRINT *,"AIRCRAFT: ",LATCLR(2,L)
     WRITE(6,700)CCSPAC(2,L)
700  FORMAT(//,"CENTER-TO-CENTER SPACING OF PARKING PADS: ",F5.0,//)
      SPAC=(HDES2(L)/2 +0.5)*CCSPAC(2,L)
      TAXWYLN=TAXWYLN+SPAC
576   CONTINUE
      IF(HPORT.NE.1)GO TO 578
     WRITE(6,795)TAXWYLN
795   FORMAT("TAXI OR TAXI-HOVERLANE LENGTH IS",F6.0" FT."//)
      TAXAREA=TAXWYLN*TAXWID(M)
      GO TO 579
578  HOVAREA=TAXWYLN*LAWID
579  IF(TYPE.EQ.1)GO TO 577
      PRINT *,"PARKING PAD GRADE IN ANY DIRECTION IS:"
      PRINT *,"       MAX OF 3 PERCENT ... MIN OF 0.5 PERCENT."
      GO TO 770
577   PRINT *,"PARKING PAD GRADE IN ANY DIRECTION IS:"
      PRINT *,"       MAX OF 1.5 PERCENT ... MIN OF 0.5 PERCENT."
      GO TO 770
585   PRINT *,"*** TAXI/HOVERLANE SPECIFICATIONS ***"
      DO 590 I=1,4
      IF(HDES(I).EQ.0)GO TO 590
     WRITE(6,701)I
701  FORMAT(//,"FOR TYPE ",I1," HELICOPTERS, LANE WIDTH IS:",/)
      IF(TYPE.EQ.1)GO TO 595
     PRINT *,"                 ",HOVWID(1,I)," FT."
     LAWID=HOVWID(1,I)
      GO TO 590
595  PRINT *,"                 ",HOVWID(2,I)," FT."
     LAWID=HOVWID(2,I)
590   CONTINUE
     WRITE(6,702)
702  FORMAT(//,"TRANSVERSE LANE GRADE IS:",/,24X,"MAX OF 5
    +PERCENT... MIN OF 1.5 PERCENT.",/)
      IF(TYPE.EQ.1)GO TO 596
     PRINT *,"THE LONGITUDINAL GRADE IS 10 PERCENT."
      GO TO 571
596  PRINT *,"THE LONGITUDINAL GRADE IS 5 PERCENT."
770    WRITE(6,780)
780    FORMAT(//,"HELIPORT APPROACH-DEPARTURE ZONE SURFACE RATIO")
       PRINT *,"IS 10:1.  ZONE LENGTH IS 1500 FEET."
       IF(HPORT.EQ.2)GO TO 785
       PRINT *,"APPROACH-DEPARTURE ZONE WIDTH AT END OF CLEAR"
       PRINT *,"ZONE EQUALS THE WIDTH OF CLEAR ZONE."
       GO TO 790
785    PRINT *,"APPROACH-DEPARTURE ZONE WIDTH AT END OF TAXI-"
       PRINT *,"HOVERLANE EQUALS THE WIDTH OF TAXI-HOVERLANE."
790    PRINT *,"APPROACH-DEPARTURE ZONE WIDTH AT OUTMR END IS 850 FT."
598 WRITE(6,703)
703  FORMAT(//,"THIS COMPLETES HELIPORT SPECIFICATIONS.",//)
      IF(HPORT.NE.1)GO TO 591
      PRINT *,"RUNWAY AREA TO BE SURFACED IS: ",RWAYSUR
      PRINT *,"SQUARE FEET."
      PRINT *,"TAXIWAY AREA TO BE SURFACED IS: ",TAXAREA
      PRINT *,"SQUARE FEET."
      PRINT *,"PARKING PAD AREA TO BE SURFACED IS: ",PADAREA
      PRINT *,"SQUARE FEET."
     AREA=RWAYSUR+TAXAREA+PADAREA
```

```
      GO TO 599
591   IF(FFORT.NE.2)GO TO 592
      PRINT *,"TAXIWAY/HOVERLANE AREA TO BE SURFACED IS: ",
      PRINT *,HOVAREA," SQUARE FEET."
      PRINT *,"PARKING PAD AREA TO BE SURFACED IS: ",PADAREA
      PRINT *,"SQUARE FEET."
      AREA=HOVAREA+PADAREA
      GO TO 599
592   PRINT *,"PAD AREA TO BE SURFACED IS: ",PADAREA
      PRINT *,"SQUARE FEET."
      AREA=PADAREA
599   RETURN
      END
```

Appendix F

REFERENCES

(1) Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations, TM5-330, AFM 86-3.

(2) Airfield Flexible Pavements, TM5-824-2.

(3) Seabee Planner's and Estimator's Handbook, NAVDOCKS P-405.

(4) Standard Facility Requirements, AFM 86-4.

(5) Facility Planning Factors for Naval Shore Activities, NAVFAC, P-80.

(6) Engineer Operations, FMFM 4-4.

(7) Helicopterborne Operations, FMFM 3-3.

(8) Surface Drainage Facilities for Airfields and Heliports, TM5-820-1

(9) Design Manual, Airfield Pavements, NAVFAC DM-21.

(10) Marine Aviation, FMFM 5-1.

(11) Planning of Army Aviation Facilities, TM5-803-4.

(12) A Land Management Technique for the Optimal Placement of Facilities in an Amphibious Objective Area (AOA, Ford, Bacon and Davis, CR 79.001, Civil Engineering Lab, NCBC, Port Hueneme, Ca., October, 1978.

(13) U. S. Department of Transportation, Soil Stabilization in Pavement Structures, A User's Manual, FHWA-IP-80-2, U. S. Government Printing Office, Washington, D. C., October, 1979.

(14) The Asphalt Institute, The Asphalt Handbook, MS4, College Park, Maryland, 1965.

(15) The Asphalt Institute, Soils Manual for Design of Asphalt Pavement Structures, MS10, College Park, Maryland, 1969.

(16) Yoder, E. J., Principles of Pavement Design, John Wiley and Sons, Inc., New York, 1959.

(17) Anderson, Joseph, "A Prototype Decision Support System for the Location of Military Water Points," M. S. Thesis, Industrial and Systems Engineering Reports Series, Georgia Institute of Technology, Atlanta, Georgia, June, 1980.

(18) Field Water Supply, Department of the Army Technical Manual, TM5-700, July, 1967.

(19) River Crossing Operations, Department of the Army Field Manual, FM 90-13.

(20) Bridging, Department of the Army Technical Manual, TM 5-210.